ESSAYS

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ESSAYS

ON

SCIENTIFIC AND OTHER SUBJECTS

CONTRIBUTED TO THE

EDINBURGH AND QUARTERLY REVIEWS

BY

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PHYSICIAN IN ORDINARY TO THE QUEEN.

NEW EDITION.

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1862.

My dear Milman,

Had our mutual friend Lord Macaulay been yet alive, I should probably have sought to inscribe to him the volume I am now publishing. Will you permit me to ask you, as one of those to whom he was most warmly attached, to give it, in his stead, the sanction of your name; and to accept this Dedication as some slight memorial of our long friendship, as well as of my admiration of those various writings with which you have enriched English literature.

Ever yours affectionately,

H. Holland.

The Very Rev. the Dean of St. Paul's

PREFACE TO SECOND EDITION.

ANOTHER edition of these Essays being called for, I have carefully revised the whole volume, and particularly the scientific articles; making such additions as seemed desirable for the more complete elucidation of the subjects under review. It is a striking proof of the rapid advancement of physical science, that even in the short interval of two months since the first edition was published, discoveries have been made known which no scientific record could rightly omit to notice. The addition of a few pages has enabled me, either in the text or notes, to advert to the more remarkable of these discoveries. I should gladly have dwelt much longer on them (as upon many other instances of the progress of physical knowledge), had not the original plan of these articles restricted me to those more general views, of which I have spoken in the preface to the former edition. To this preface I may perhaps be allowed to refer the reader, in explanation of the circumstances under which they were written, and the objects they were intended to fulfill.

July 15, 1862.

will be seen to have relation to the progress and actual state of the physical sciences. Written with the object of such illustration, they will, I trust, be read under the same view; — that is, not as formal treatises on these several subjects, but as general outlines, denoting the new methods and spirit of modern research; the more recent and remarkable discoveries in each science; and those mutual connections of all, the knowledge of which is among the highest attainments of man in his study of the natural world around him.

In these Articles, more purely scientific, many alterations have been required; — partly from the rapid growth of physical knowledge since they were first published;—partly from the collected form in which they now appear. Various additions have been made, either in the text or by notes, to remedy deficiencies from the former cause; — many omissions also, to obviate the repetitions which could scarcely be avoided in papers written at different times, and for different Reviews. To meet the same requirements, I have further, in several cases, transferred portions of one article to another; or even taken parts from essays not included in this volume. A few anachronisms will probably still be found; but none such, I trust, as can create error or embarrassment to the reader. Certain repetitions also may be noticed (as with regard to the influence of the Atomic doctrine on Modern Chemistry); but these will be seen to depend on the particular object of the first Essay, which, treating of physical science at large, necessarily took its illustrations from the several branches of science composing this great whole.

The topics actually discussed in these papers are so various, that it has not seemed needful to place them in the order of their original publication. Nor have I attempted other arrangement than that of bringing together, in one or two cases, those which have some slight affinity of subject.

I have already avowed a certain feeling of personal interest in many of these Essays, from their association with various scenes and incidents of travel, and with some localities which belong to the history of the world. This interest I cannot expect to convey to others, and the papers must therefore rest on whatever value they may themselves happen to possess. It would be false modesty not to mention that I have been asked to publish them thus together, by several persons whose opinion I have every reason to respect. To one of these — a dear friend, and, in later years, a family connection — I should probably have ventured, had he happily still been living, to dedicate this volume. Yet I might well have hesitated to do so, from the fear of provoking a comparison with those admirable Essays he himself contributed to the 'Edinburgh Review;' the volumes containing which form one of the precious bequests he has made to the language and literature of his country.

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ESSAYS

SCIENTIFIC AND OTHER SUBJECTS.

THE PROGRESS AND SPIRIT OF PHYSICAL SCIENCE.*

[Edinburgh Review, July 1858.]

ALMOST every age of human history has either given to itself or received from posterity, some epithet marking, whether truly or fancifully, its distinctive place in the records of the world. It would be easy to find and to apply many such epithets to the remarkable period in which our own lot is cast; abounding, as it does, in characteristics which distinguish it from any that have ever gone before. One, which we cannot doubt that our own posterity will adopt, inasmuch as it affirms a fact equally obvious and certain, is, that we are living in *an age of transition*;—a period when changes, deeply and permanently affecting the whole condition of

* 1. *Essays on the Spirit of the Inductive Philosophy, the Unity of Worlds, and the Philosophy of Creation.* By the Rev. Baden Powell, M.A., F.R.S., &c., Savilian Professor of Geometry in the University of Oxford. London, 1855.

2. *The Co-relation of Physical Forces.* By W. R. Grove, Q.C. M.A., F.R.S., &c. Third Edition. London, 1855.

3. *On the Conservation of Force.* By Professor Faraday, D.C.L., F.R.S., &c &c.

4. *Essays from the Edinburgh and Quarterly Reviews.* By Sir John F. W. Herschel, Bart. K.H. London, 1857.

5. *Nomos: an Attempt to demonstrate a Central Physical Law in Nature.* London, 1856.

mankind, are occurring more rapidly, as well as extensively, than at any prior time in human history. The fact is one which lies on the very surface of all that we see in the world around us. No man of common understanding, even in the narrowest circle of observation, but must mark the continual shifting of things before him; reversing, in many cases, the maxims and usages which are the inheritance of centuries, and altering in a thousand ways the present conditions of material and social life. The philosopher who looks from a higher level, and upon a more distant horizon, discerns in these changes a wider and more lasting influence. He sees that they involve the relations of races and communities of men over the whole face of the globe; and that they are destined, sooner or later, to obliterate many of those diversities and lines of demarcation, which, however originally produced, seemed almost to dissever the species, in the contrast of human existence they afford. He takes further note of what is the great agent in this and other changes, that wonderful progress in physical philosophy, which has placed new powers in the hands of man - powers transcending in their strangeness and grandeur the wildest fables and dreams of antiquity, and the effects of which are already felt in every part of the habitable earth. He sees the march of discovery continually going on; new paths opened; new instruments and methods of research brought into action; and new laws evolved, giving connection and combination to the facts and phenomena which unceasingly accumulate around us.

Closely, or even necessarily, connected with the changes last denoted, is the topic to which, as suggested by the works before us, we would especially invite the attention of our readers. We allude to the concurrent changes taking place in the spirit and scope of physical philosophy at large; scarcely less remarkable in their nature and influence than

the discoveries in which they originate, and by which they are sanctioned. Modern science, in its dealings with the great physical powers or elementary forces which pervade the material world, has been led, or even forced, into a bolder form and method of enquiry. Inductions of a higher class have been reached, and generalisations attained, going far beyond those subordinate laws in which science was formerly satisfied to rest. Experiment and observation, as the agents in acquiring knowledge, must always to a certain extent be alike in their objects and methods of pursuit. But the precision and refinements of modern experiment — partly due to greater perfection of instruments, partly to the higher principles on which enquiry is based — strikingly distinguish it from that of any anterior time. With every allowance for illustrious exceptions, it is impossible to make the comparison, and not to see that the physical researches of our own day have a larger scope and more connected aim than heretofore; - that experiment is no longer tentative merely, but suggested by views which stretch beyond the immediate result, and ever hold in sight those general laws which work in the universe at large. Nor is any power so gained permitted to be dormant or inert. If thought suggests experiment, experiment ministers fresh materials to thought; and the philosopher working boldly with the new forces at his command, and under the guidance of hypotheses which extend to the very confines of human intelligence, obtains results which almost startle the imagination by the inroads they seem to make on the mysteries beyond. When flying along the railroad at forty or fifty miles an hour, with a slender wire beside us, conveying, with speed scarcely measurable, the news of nations, the demands of commerce, or the fates of war, we have an example (though few estimate it fully) of those mighty attainments which bind to do our bidding, elements before unknown or uncontrolled by man,

and which give certainty of other and similar attainments in time yet to come.

Admitting that hypothesis, and this often of adventurous kind — the '*animi jactus liber*' — blends itself largely with the recent progress of physical science, we would in no way impugn this powerful instrument and aid of research; the use of which, under due limitation, is justified equally by reason and experience. In all enquiries of this nature, except those strictly mathematical, certainty and conjecture necessarily and closely commingle. The speculation or bare analogy of one day becomes the scientific induction of the next; and even where hypothesis is not thus happily fated, it still has often high value as an interpreter and provisional guide to the truths sought for. All sciences, and very especially those of optics, chemistry, and electricity, furnish notable instances to this effect; and have rescued hypothesis, in the philosophical sense of the term, from the reproach which it was once the fashion to cast upon it. Such vindication, however, affords no sanction to that spirit which pushes mere speculation far in advance of experiment and observation, and adventures rashly into fields not prepared for human culture, if indeed ever accessible to it. Eccentric theories of this kind, the produce of imperfect knowledge or illogical understanding, will ever be found in the path of science; perplexing, it may be, to those who loosely follow it; but disappearing one after another, as truth pursues its steady course amidst them. The mysteries of organic life, approached with caution by the true philosopher, are an especial seduction to these framers of new systems; — systems which it becomes easy to coin, under shelter of a vague phraseology, and aided by the very obscurity of the subject with which they deal.

While speaking thus generally on the spirit and methods of modern science, we may notice the fact, that there is

scarcely one of the legitimate hypotheses of our own time, or even any great law founded on the soundest inductions from experiment, which is not prefigured in some way, more or less distinctly, in the philosophy of former ages. We might, had we space for it, give many curious instances of these anticipations; and assign reasons why they should especially be found in the more recondite parts of philosophy, such as the origin of matter, the qualities and combinations of atoms, the theories of space, ether, forces, &c., — transcendental questions which press themselves upon the thought of the metaphysician, as well as of the naturalist and mathematician, in contemplating the phenomena of the universe. The astronomy of the Greeks indeed, even unaided by the telescope, went beyond all other science of the time; and the great names of Aristotle and Archimedes stand out in antiquity as men who knew the value of exact observation and experiment in the study of nature. But it was chiefly through the avenues of thought and speculation, little aided by experiment or systematic research, that the subtlety of a few rare spirits in each early age came upon the traces of physical truths, which modern science has approached by more certain roads, and made the lawful prize of inductive research. What then were but hasty and transient glances into these profound parts of philosophy have now become a steady insight into the great physical laws under which are embodied all the phenomena of the natural world.

We have placed at the head of this article the titles of several recent works, well fitted, by their various merits and by the eminence of their authors, to illustrate the view we have briefly given of the present aspects of physical philosophy, as well as to indicate those future prospects of science, which may fairly be inferred from the spirit in which it is now pursued. We might largely multiply the number, were

we to include even a small proportion of the systematic or elementary works; — the lectures, memoirs, and addresses to scientific bodies — or the articles in periodicals, which, under the influence of this new vigour of enquiry, and the practical popularity of many of its topics, have opened their pages to meet the demand for more familiar information than scientific treatises can afford. These topics, in fact, include not only the sciences treating of the simpler inorganic conditions of matter, and the elementary forces (heat, light, electricity, gravitation, and chemical affinity) which act upon the material world; — but also animal and vegetable physiology in their whole extent, and those wonderful laws of organic life, connecting matter with vitality, instincts and intellect, under the numberless forms and species which are placed before us for our contemplation. In surveying this vast field of natural knowledge for the purposes just indicated, we must of necessity limit ourselves to a broad outline; thereby forfeiting in some part the interest which belongs to the familiar illustrations of each particular science, but gaining in compensation a more comprehensive view of the relation between the different sciences and of those great discoveries in all which are ever tending to bring them into closer connection and subjection to common laws. We need scarcely dwell on the importance of such general views, and their influence on the spirit and progress of physical philosophy. We shall have occasion immediately to illustrate it, in speaking of the efforts made by some of the most eminent men of science of our day to give concentration and unity to classes of phenomena hitherto regarded as having no co-relation or common principle of action.

We do not undertake to analyse in detail, or even to notice, all the works before us. To one of them, however, the Essays of Professor Baden Powell, we must refer, as expounding more distinctly than any other, that present spirit

and scope of physical science to which we have just alluded. In the first of these Essays, Mr. Powell describes the doctrines he advocates under the titles of 'Unity of Sciences,' and 'Uniformity of Nature,'—terms meant to express, but expressing too strongly, those admirable generalisations which have connected under common laws phenomena seemingly the most remote and unlike, and are continually tending still further so to connect them. Taking the subject in this general sense, we cannot hesitate to regard it as one of the very highest which can be submitted to the human understanding. The unfulfilled objects of science, as well as its ultimate end and aim, evidently lie in this direction; and none can be indifferent to the wonderful results which every year is disclosing to researches pursued on this principle. Among those who have laboured most successfully for this especial object are the eminent men whose discoveries in particular branches of science have given them merited fame in the world. If out of many contemporaries we were to select a few who have done most to elevate physical science by generalisation of its phenomena and laws, the names of Arago, Faraday, Herschel, and Humboldt occur at once as first in this career. These philosophers have looked upon the world of nature in its largest aspects, and made their several discoveries subservient to this great object; thereby widening the circle of facts and phenomena, and at the same time drawing them more closely towards that centre in which we find so many sciences to converge.

Nevertheless we must not allow these terms of 'Unity of Science,' 'Unity of Principle,' and 'Unity of Law,' to usurp too much on the understanding. Professor Powell gives undue force to such phrases; which, strictly examined, have no reality in our actual knowledge. It is true that there is various high authority for their use, as for that of language analogous in effect. Humboldt, in several passages of his

'Cosmos'—and, at an earlier period, D'Alembert and Laplace, — have sanctioned the general conception, though not really defining it beyond that attempt at generalisation just noticed; and which would have existed even if no such mysterious word as 'Unity' had been used to signify the ultimate end in view. We readily admit it as probable or certain, that numerous facts hitherto insulated or anomalous, and even whole classes of phenomena unexplained by science, will hereafter be submitted to common and known laws. And we further believe that many laws themselves, now of partial application, will hereafter merge in others of higher scope and generality. We shall speedily have to notice certain cases where this amalgamation has so far advanced as to furnish an entirely new basis for research, scarcely seen or anticipated before. But admitting what we have full right to presume, that this concentration may yet be carried much further, still the attainment or even the conception of unity, in any strict sense of the word, lies indefinitely beyond; shrouded by an obscurity which words may seek to penetrate, but which human intellect can reach only in that one sublime sense of the unity of the Divine Creating Power. We may reduce to a small number the many forms of matter which are elementary to our present knowledge; — we may show the identity of certain forces, hitherto deemed elementary, by their mutual convertibility; — we may accept the phrase of Laplace, 'Les phénomènes de la Nature ne sont que les résultats mathématiques d'un petit nombre de lois immuables;' and yet we shall never prove that there is but one kind of matter or one nature of force, or that a single law governs all the phenomena around us. To put forward, therefore, the phrase and conception of 'Unity of Science' as the final term of our labours, is to inflict a metaphysical issue upon them, for which there is no warranty either in reason or practical use. Bishop Berkeley has somewhere

spoken of ultimate ratios in mathematics as the 'ghosts of departed quantities.' With like reason we might call the unity of some of our recent philosophers the 'ghost of departed pluralities;' having this quality of ghosthood, moreover, that there is nothing truly tangible or substantial about it.

We have dwelt thus much on these preliminary topics because, while they indicate what may be considered the exaggerations and excesses of theory, they show at the same time that spirit and propensity of modern science of which we have before spoken; and which, duly regarded, has been the source of all its high attainments. We now proceed to such details as may best illustrate this spirit in its application to different branches of science; selecting, amidst the multitude of examples, those especially which involve either some new physical principle or some new method of physical enquiry. It has been said by one who could well estimate the value of the latter, 'La connoissance *de la méthode* qui a guidé l'homme de génie, n'est pas moins utile au progrés de la science que ses découvertes.' A new method is often indeed in itself the greatest discovery, and betokening the highest genius in him to whom it is due.

In dealing with this wide subject, the first and most material division is that between the Forces acting *on* or *in* Matter; and the various forms of Matter; inorganic or organic, so acted upon. With full admission of the difficulty of defining the abstract nature of matter and force, and their mutual relations in the universe, this distinction is still the only one which our intelligence can apprehend or practically apply to the objective phenomena ever present and active around us.

In regard to matter and force it may undoubtedly be affirmed that all questions as to their nature become more

difficult and abstruse in proportion as we generalise and reduce them to their simplest terms. With respect to force, more especially the most eminent philosophers of our time, while declining any metaphysical definition, have been constrained to adopt new methods of regarding and describing it, in those various actions upon or through matter which testify to its presence and energy. Centres of force (an expression due to Boscovich in its scientific use), lines of force, polar force, &c., are terms found necessary to express the several modes of force in action, irrespectively of all questions as to its abstract nature, or especial relations to matter. Under the gradual adoption of this new language, there has been a corresponding abandonment of phrases, more hypothetical in themselves, and far less fitted to aid the progress of scientific enquiry. As such we may denote that expression, current even in some of our best systematic works, of the 'imponderable substances or forms of matter;' which, as describing heat, light, and electricity, makes assumptions wholly unproved; and in excluding gravitation, chemical, mechanical and vital forces from the same category, affirms a distinction which we do not absolutely know to exist. For the notion of an *imponderable element* (if notion it can be called) that of a *mode of change, or motion of matter*, might probably in all these cases be more truly as well as advantageously substituted. Such phrase better defines the present limit of our knowledge, and marks a possible path of progress beyond. Science, it may fairly be said, is constantly tending to a closer form of logic in these matters; and simple induction from facts, unfettered by names and prior notions, is here as elsewhere the best guide to all ulterior discovery.

The great problem respecting force in the most general conception of it as a motive power on matter, is involved in the question, whether it can ever really be lost or extinguished, or even lessened? or whether the seeming cessation

and limits to its action are not merely conversions or translations of power, testified in other forms and effects of material change? Most persons, justified by outward appearances, would answer at once that a force has ceased to exist, when the motions or other effects it induces on matter are no longer present. The question, however, is one which rises far above the mere evidence of the senses. Vaguely suggested at former periods, it has been adopted in a definite shape by the philosophers of our own time; forced upon them, we may say, by the course and character of recent discovery. It is the question which forms the main topic of Mr. Faraday's lecture, which lies before us, on the 'Conservation of Force;' and we willingly quote a few lines, both from the intrinsic weight of all that comes from this source and as expressing what we consider to be the growing conviction of all who have grappled with this great problem of modern science.

> To admit that force may be destructible or can altogether disappear, would be to admit that matter could be uncreated, for we know matter only by its forces. Agreeing with those who admit the conservation of force to be a principle in physics as large and sure as that of the indestructibility of matter, or the invariability of gravity, I think that no particular idea of force has a right to unlimited or unqualified acceptance, that does not include *assent* to it. . . . Therefore I urge, that the conservation of force ought to be admitted as a physical principle in all our hypotheses, whether partial or general, regarding the actions of matter.

This question, as we have said, was forced upon the attention of men of science by the very nature of their recent researches, and especially by the doctrine based upon them, which is now developing itself under the title of the 'Correlation of Physical Forces;' a description modest as well as apposite of a theory, which if matured, as we think it certain to be, into full truth, will give new foundation and guidance to the whole course of physical enquiry. In the work of Mr. Grove, bearing this title, and prefixed to our article, we have

the first and most able exposition of the doctrine. Partial suggestions of it, both in England and Germany, had already occurred; but we owe to Mr. Grove its distinct enunciation as a physical principle, and the illustration of this principle by instances drawn from his own researches and those of others, which give it all the characters of a new physical law. His work, of which the third edition is before us, is remarkable, not only for the bold and exact logic of its inductions, but also for its clearness and simplicity of style; qualities valuable in all scientific writings, and essential on subjects like those here treated of.

By the term co-relation, as applied to physical forces, Mr. Grove means to convey the general idea of *reciprocal production*;- that is, that any force capable of producing another, may reciprocally be produced by it. But the principle here involved, as well as its wide scope, will be better understood by taking co-relation to express generally those relations of forces which render them mutually and constantly convertible — one form or manifestation of force generating another, so as to bring together into the same series of effects, physical actions and changes seemingly the most remote and dissimilar. Thus, to take a familiar but striking instance. The same single electrical current from a voltaic battery is capable in its circuit of evolving heat and light —of creating magnets —of producing mechanical force —of violently affecting the nervous and muscular organisation — and of inducing, by decomposition or combination, the most powerful chemical changes—simply according to the nature of the different material objects which the experimentalist interposes in the circuit, so as to subject them to this current of power. Here then (gravitation excepted) we find all the great natural forces, of which we have present knowledge, evolved from a single source; and that source, be it remarked, a chemical change of affinities, giving origin

to the electrical current, and thereby affording fresh proof of the reciprocity of actions alluded to above. One form of force always disappears as another is evolved.

We might give, had we space for them, many other curious instances of this reciprocity of relation, as manifested by the several forces of heat, electricity, magnetism, mechanical power, and chemical affinity. One we may select, as an example of beautiful contrivance as well as striking results. By a certain combination of apparatus, in which light, acting through the daguerreotype, was the initiating force, Mr. Grove obtained first the *chemical action* upon the plate; thence a current of *electricity* circulating through wires; next *magnetism* by a coil of these wires; then the production of *heat*, testified by the delicate helix of Breguet; and finally, *motion*, as shown by the needles of the galvanometer. Instances of this kind have rapidly multiplied, since the co-relation and convertibility of forces has been recognised as a principle and applied to research. They are derived not solely from recent experiment, but even more frequently and fruitfully from phenomena already familiar to us as facts, but which awaited for their illustration the happy induction now attained.

The beauty of this principle, however, is not limited to the expression of the reciprocity or mutual convertibility of the physical forces with which we are dealing. There is every reason to believe in a further co-relation as regards their equivalents of power or measurable quantitative effects. Though this generalisation is still not complete, numerous cases occur where it is thoroughly attested by the results of experiment. The discoveries of Faraday have furnished some of the most striking examples of constant quantitative relation between electrical power and chemical actions and changes. The researches of Dulong, Petit, and Neumann, show very remarkable relations between chemical affinity and heat,

in proving that the specific heats of certain substances, compound as well as simple, when multiplied by their chemical equivalents, give a constant quantity as the product. And again, the experiments recently made by Mr. Joule and Professor W. Thomson, on the mutual convertibility of heat and dynamical force, demonstrate the remarkable fact that, in whatever way mechanical force is employed to produce heat, the same amount of heat is produced by the same amount of force. We doubt not that the progress of science will so multiply the number of these instances of quantitative relation and equivalents of power, as ultimately to submit them to some general law, as well as to practical application in various forms. The very phrases, if duly weighed, show that approach to mathematical proof, which is the surest test of truth. Where we can bring numbers to verify results obtained, and to predict results sought for, we may be certain that we are treading on safe ground.

It will be noticed that we have not hitherto spoken of Gravitation as a physical force; though it is the one with which we are most familiar in every incident of life, and to which we look as the most universal agent upon matter, as well on the globe we inhabit, as in the innumerable worlds surrounding us in space. We place it apart from other physical forces, because, while thus familiar to our senses in its effects, it is to our deeper meditation the most mysterious as well as vast and sublime of the powers which act in the universe. Human genius has discovered and mathematically defined its laws. By knowledge of these laws, human science has been carried, and is ever penetrating farther, beyond our own planetary system; while within this system, they have enabled us to predict events in time and space, and to define physical conditions of the planets and their satellites, seemingly unapproachable by man. With all this knowledge and perpetual application of the power,

of its nature and essence we are utterly ignorant. Science has dealt with its effects only, without really approaching a step nearer to the cause, than when Newton declared that he must leave to the consideration of his readers the question whether the agent producing gravity was material or not. Hypotheses have grown up — such as that of *gravific atoms* permeating all space, of Le Sage; or the *residual force* theory of Mosotti, connecting gravity with molecular attractions — but none which satisfy fully the exigencies of the case. The research is even made more difficult by the simplicity and invariability of the power in question. It evolves in certain cases, and constantly controls or modifies, the other forces acting on matter; but has no such relations to them as they have to one another; — no reciprocal production or mutual convertibility; nor the *duality of action* belonging peculiarly to the electrical and magnetic forces; nor lines of propagation and polarisation, such as we recognise in light and heat; nor those molecular changes manifested in acts of chemical affinity. Whether any — or if any, through what new avenues — closer approach may hereafter be made to the solution of this great problem of gravity, bringing it into closer connection with the other great forces of nature, we cannot here enquire. But in speaking of the forces which act upon matter, it was impossible to omit this the most universal of all — innate and incorporate we might almost say, in matter itself.

Nor can we rightly avoid in this place some allusion to the equally abstruse subject (though rendered so by very different causes) of the mutual relations of the physical and vital forces — a topic handled with great ability by Dr. Carpenter, in a paper in the 'Philosophical Transactions,' a few years ago, and more recently in the systematic works of this physiologist. Without going into the depths of this question, we may say that the tendency of all recent research has been to

impugn the doctrine of vitality, both in animal and vegetable life, as a distinct force or power; and to resolve its alleged functions, whether of organisation, maintenance, or reproduction, into those same physical forces which act on the inorganic matter of the world around us. That this is true to a certain extent cannot indeed be doubted. That heat and light, and more especially the former, are intimately concerned in all the phenomena of vital organisation, is a fact familiar to us from a thousand examples. The researches of Liebig and others have shown how very closely chemical processes are engaged even under the strict law of definite proportions — in all the great processes belonging to animal life, assimilation, secretion, respiration, animal heat, &c.; while the discoveries of Matteucci and Du Bois Raymond have demonstrated the curious and exquisitely subtle relations which exist between electricity and the nervous and muscular functions; not indeed proving the identity of electricity with the nervous element of force, but countenancing this view beyond all prior expectation.

In thus discussing the relation of the physical and vital forces as applied especially to man, we continually approach that line, hard indeed to discriminate or define, which separates the mere vital or automatic acts from the proper functions of mind, consciousness, thought, feeling, and volition. On this debatable land we encounter at once the old questions, so long the subject of philosophical speculation, and destined, as far as we can see, ever so to remain. Human science on this point is as feeble as it was two thousand years ago, and beset by exactly the same difficulties. We have just been speaking of forces which are co-related and measurable in their effects. We come here to powers and functions *wholly incommensurable* either with material qualities or physical forces; yet so linked with both under the present conditions of existence, that not even personal consciousness,

on certain points the surest of all teachers, can mark any clear boundary line. Those who have sought to decipher or define these proximate relations of matter and mind have but substituted barren words for the realities of knowledge. Mr. Baden Powell himself, while stretching the domain of physical causes to the total phenomena of animal life, yet finds a limit here; and somewhat abruptly closes his argument by observing that the assertion of a moral and spiritual nature in man refers essentially to '*a different order of things*, apart from and transcending any material ideas whatsoever.' To some such conclusion, however expressed, all must come who honestly and reasonably approach this question.

We have dwelt thus long on the subject of the physical forces — the 'imponderables' of former systems — as illustrating at once a great doctrine of modern science, and the general spirit of philosophy at the present time. We are far, however, from having exhausted the subject. Questions crowd round and converge upon it from every side; some of these so subtle in kind that we might well call them metaphysical, but for the caution ever needful in admitting this term into the domain of science. Such are, to state briefly a few of them, the question whether forces can exist, except in connection with matter, and manifested by its changes? — whether what we call forces may, intelligibly and consistently with phenomena, be regarded simply as molecular actions, or modes of motion in matter? — whether (to revert to a question urged before) they can ever by possibility be annulled or even rendered latent? — whether, in admitting this constant combination and convertibility of forces, we do not virtually admit a *constant amount* of force, variously manifested, to be always present in the universe? — and whether, in such case, we can ever rightly speak of an *initial force*, otherwise than in the sense of those acts of

creation in which all human knowledge ends? These and other like questions belong to the philosophy of our day; some of them shadowed out in the hypotheses of antiquity; now approached through the safer avenues of experiment and sound induction. How far these may lead us to the future more complete solution of the problems suggested we cannot here stop to enquire.

In passing from the province of Forces acting on matter, to that of Matter thus acted on, we have yet to traverse another debateable ground, on which science is seeking to find some firm footing, as well in explanation of known phenomena as for purposes of further research. We allude here to the question regarding the *physical condition of space itself*;—of those inter-planetary and inter-sidereal distances, some of them hardly measurable by numbers, and such, in truth, as no effort of mind can compass or conceive. Are we to regard this vastness of space as void of matter — a mere vacuum, through which the numberless worlds we see as stars or planets are dispersed? Or may we better contemplate it as pervaded throughout by some material medium, though so rare and attenuated, that no form of matter of which our senses are cognisant can rightly interpret it to our reason? The question must no longer be argued in that mystical language of 'nature abhorring a vacuum,' which satisfied the demands of an earlier philosophy. Nor can we evade it by the adoption of terms such as *ether*, *ethereal medium*, &c., which, though sanctioned by some great names, go little further than to shelter a vague and incomplete solution. Modern science seeks urgently for proof that matter, in some condition, does exist throughout space; and in such continuity, however rare it be, that forces may be transmitted *by* or *through* the medium thus afforded. Two great powers, gravitation and light, undoubtedly reach us from the most

remote regions of space. There is presumption, approaching to certainty, that heat is associated with light in its origin, as a concomitant, if not convertible force. More doubt exists as to the transmission through space of the electric or magnetic powers; but numerous observations tend to justify this belief, and such facts, as we shall see hereafter, are every day multiplying around us.

How then are these forces, or any of them, transmitted to and fro in the universe? If we say that the tides of the ocean are raised, or the perturbations of a planet produced, without any intervening medium between the bodies affected and those affecting them, we quit the domain of physics altogether, and put an abrupt end to enquiry. Newton has expressed himself strongly on this matter, in saying, 'To suppose that one body may act upon another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it.' The conviction which his conception of gravity thus impressed on Newton's mind, is enforced upon us not less cogently by the undulatory theory of light. This theory — based on mathematical proof, and capable not merely of explaining phenomena before known, but of *predicting* others evolved by later research — presumes of necessity the existence of an elastic medium, whatever its nature, through which these undulations are transmitted. We say *of necessity*, because it is logically thus to our reason. Not solely on the analogy of air and other elastic media, but as the only conception we can form to the mind of undulation singly considered, the presence of a medium is essential to its existence and effects. And this fully recognised, the inferences become of magnificent kind. The progressive retardation of Encke's comet, the aspects

of the zodiacal light, and the numberless meteorites traversing the sky, afford presumption of such material media everywhere existing within our own solar system; but the argument we have just stated carries us far beyond this limit, to the most remote parts of that sidereal and nebular space from which light reaches the eye of man. We might bring the phenomena of heat into evidence on the same point; though less strikingly and conclusively than those of gravitation and light, of which we have just spoken.

In coming finally to those several sciences which deal with Matter in its more recognised forms, we must once again repeat that our object is simply that of indicating the spirit and scope of modern science, as illustrated by its new objects and methods, and by the high attainments at which it has arrived. Volumes would be needed to give even an approximate idea of the particular discoveries, whether from experiment or observation, which have conduced to these results. In the hasty view we are taking, we can but notice such as are most striking in character. Nor are we called upon to do this methodically; since, as already mentioned, one of the most eminent successes of our time is that of having brought all the branches of physical science into closer connection and subordination to more general laws; and in illustrating these new connections, examples crowd upon us from sources seemingly the most remote.

Humboldt, in his Cosmos, has rightly given to Astronomy—'the science of the universe without'—the first place in his picture of physical knowledge. So much has lately been written on this science—the highest glory, it may well be deemed, of the human intellect—that we need only allude to a few of its more recent attainments; not surpassing indeed those discoveries which we owe to the genius of a prior time, yet so extending the doctrine of universal gravi-

tation in the variety and refinement of its applications, that new grandeur is given to this great law of nature. We may take one or two examples, among many that offer themselves, from our own planetary system; where this power is more within our cognisance, both in its simple effects and in those complex perturbations of orbits, which have taxed, but not overcome, the efforts of mathematicians. The first instance — one of those familiar to the world for the moment, but speedily forgotten — is a discovery made by means of these very perturbations. The movements of Uranus, then (1846) supposed the most remote planet of our system, were found to be disturbed by some external influence not referrible to causes *within* its orbit, as could be shown; but due to some material attraction from without. Another planet alone could answer these conditions. Science set itself to work in the persons of two eminent mathematicians, Adams and Leverrier; — the position of the disturbing body was determined by them simultaneously, but independently; — telescopes followed their guidance, and Neptune was added to the number of our planets. The method of discovery here has higher interest than the fact itself; though now but one of numerous instances in science, where results can be predicted with hardly less certainty than if attained and present to the senses.

A second example we may cite, in proof of the exactness, or even *delicate minuteness*, with which modern astronomy pursues the vast objects of its science. The complex irregularities of the Moon's motions have long put to test all the resources of analysis, and are scarcely even yet fully submitted to our knowledge. Chiefly, of course, they depend on the relative position and distances of the sun and earth; and Laplace had shown, not only the secular acceleration of mean motion, produced by the increasing eccentricity of the earth's orbit, but also a small irregularity depending on the

spheroidal figure of the earth itself. His suggestion that the oblateness of the earth's spheroid might reciprocally be determined by this irregularity of the moon's motion led Burg to a calculation, the results of which closely tallied with the best measurements and pendulum observations. Very recently new and more delicate causes of lunar disturbance have been indicated, as depending on the action of the planet Venus;—first, indirectly, by its perturbing the motion of the earth, altering our distance from the sun, and thereby affecting the motion and position of the moon during periods of 120 years;— secondly, by a minute disturbance arising from the *direct* action of Venus on the moon itself. In all these cases the theory accords with the phenomena observed; and this accordance well illustrates the perfection of use which the great law of gravitation has now attained.

In passing the bounds of our own system — *narrow*, we may call them, in relation to what lies beyond — we lose in great part the guidance of this law; though retaining such proof of its equal and probably similar operation in the most distant regions of space, as almost to force upon us the conclusion (warranted indeed by other considerations) that Motion is universal and constant in all matter — that nothing in the universe around us is at absolute rest. To prove the continuous movement of the solar system in space, with the direction and rate of its motion; — to confirm this wonderful fact by the discovery of the proper and absolute motions of other stars; — to determine by parallactic observations of incredible delicacy the distances of certain of the fixed stars, and to measure these distances by the *years* which light takes to traverse them; — to demonstrate, among the many thousand double or multiple stars now discovered, those orbits and periods of revolution which obey the same law that brought Newton's apple to the ground;—to *gauge* by refined processes our own nebula of the Milky Way; — to discover

and assign the place of more than 3,000 other nebulæ, resolving many of them into systems of stars, and by admirable methods obtaining some approximate idea of their distances; — these have been among the undertakings of modern sidereal astronomy; admirably fulfilled by the eminent men who have devoted themselves to this science, the two Herschels, Struve, Bessel, Airy, Argelander, Peters, &c. Sublime even, in their simplest enunciation, these problems will be seen to involve results as to space and time which border on infinity; and as such illustrate well those arduous aspirations of modern science which it is our present object to indicate.

Though not easy in a science like this to set limits to its future scope, yet is it difficult to suppose any ulterior discovery which can do more than aid in filling up this vast outline. If new laws are discoverable in our own system, we may perhaps presume them to relate to the rotation of the planets on their axes, and to their respective densities ;— an important series of facts arbitrary to our present knowledge, but doubtless due to determinate physical causes, and therefore open to physical research. It is *possible*, seeing the distances some comets reach in their aphelia, that another planet may exist even beyond Neptune; which discovery, if ever made, would be so through the observed perturbations of Neptune itself. Certain irregularities in the orbital motions of Mercury have led Leverrier to suspect the existence of an inferior planet, or masses of matter, still closer to the sun; but no actual observation has yet been made which can be admitted as verifying this idea.

In the Sidereal system, of which our solar system forms a single part, much yet remains for future completion. Nothing is more wonderful than the phenomena, periodical or otherwise, of the variable stars, which are now largely catalogued in our books. Ages may be required to gather any certain

induction from our observations upon them. But ages are the field in which the astronomer works; and each present fact, dûly recorded, ministers to the higher knowledge, which is the harvest of the future. The research into the proper motions of the stars, already noticed, is sure to be greatly extended, and may possibly connect itself in the end (as Mädler has already sought to connect it) with the discovery of some centre of attraction and movement to the whole sidereal system. If such central body or point in space were ever ascertained, it would still be simply an expression of the law of universal gravitation; but how sublime an expression, and how wonderful as a result of the genius and labours of man!

But the limit does not lie even here. The telescope of the astronomer, enlarged in its powers and more perfect in all its appliances, is continually engaged among those other sidereal or nebular systems, the remoteness of which goes far to express all that man can ever conceive of the infinite in space. Whoever has inspected the admirable *portraits* of nebulæ, as seen through Lord Rosse's great reflector, will comprehend in part the magnitude of this research, and of the problems it puts before us. The aspects and multiplicity of the spiral nebulæ, though hardly sanctioning the notion of any new law of matter, yet well warrant the belief in some common but unknown cause conducing to this singular effect. A matter of still higher interest is suggested to us in the question, whether there exist in these nebulous lights, or elsewhere in space, matter not yet condensed or shapen into forms — the material, it may be, of future worlds, and in different stages of progressive concentration, but still not aggregated as such. The resolution into clusters of stars by high telescopic power, of many nebulæ before thought irresolvable, alters the degree of presumption, but does not settle the question. The comparison of different nebulæ, as they now exist, and of their several relations to centres or points of greatest condensation,

would seem the sole probable avenue to further knowledge; since any changes in the figure, condensation, luminousness, or other aspects of these nebular systems must, upon every analogy of the more proximate parts of the heavens, occupy such immense periods of time as to place them beyond all present reach. And we know too little of the duration of our own species on the earth to venture on any assumption thus remote in its fulfilment.

These questions as to nebulous matter in space are deeply interesting, *retrospectively*, as well as *prospectively*, in time. Few subjects have so keenly exercised speculation of late as the hypothesis, first sanctioned by Laplace, that our own solar system, with its central sun, planets, moons, and comets, has its origin in the concentration of the matter of a nebulous sphere in successive zones; each several planet being formed by the condensation of vapour at these successive limits in the plane of a common equator; and the satellites being similarly formed from the atmospheres of the planets. It does not annul this theory to admit that there are great difficulties in conceiving the cause of such aggregation of matter at certain points, and of the permanent movements impressed on the bodies thus formed. These difficulties, whatever they be, have not prevented its eager appropriation by philosophers who hold the doctrine of progressive developement according to certain determinate laws, in the creation both of the inorganic and organic world. They find a basis for the evolution or transmutations they suppose, in this hypothesis of the nebular origin of suns and planets; and their argument would be plausible were the hypothesis itself capable of being verified. How far presumptive evidence may reach in future towards such verification, we do not venture to say; but the sources of fresh knowledge are ever opening in this as in other directions of research. The more careful study of cometary phenomena; of the numerous planetoids revolving

in excentric orbits between Mars and Jupiter; of those meteors, some of which have lately been recognised as periodical in occurrence; and of the aerolites, which impinge in mass upon the earth,— can hardly fail to settle the questions as to the occupation of planetary space to which we have already alluded. How curious, for example, the inference to be drawn from the composition of these falling stones, brought to us undoubtedly from far beyond our own atmosphere, or, as Laplace boldly phrases his belief, 'des profondeurs de l'espace céleste!' Of the various ingredients they are found to contain, every one is familiar to us upon the surface of the earth we inhabit. They represent, indeed, fully one-third of those forms of matter which are still simple or elementary to our knowledge; though under different aspects and forms of combination. Here then we have a sort of *material ingress* into the regions of interplanetary space; and presumption as to a common origin, though under different modes of aggregation, not merely of those fragmentary masses which casually reach us, but of the great planets also, which move with ourselves in orderly and determined course around the sun.

We are tempted to add one or two other instances here, illustrating the manner in which modern science — resting upon the uniformity of laws, whatever the scale of their operation — has brought evidence to bear upon these vast astronomical questions from the most minute manipulations with matter here below. The happy idea occurred to M. Plateau of Ghent of suspending globules of oil within water, rendered exactly of the same specific gravity by addition of alcohol, so that the globules should be wholly exempt from the action of gravity or other extrinsic force, and free to take any position or motions impresed upon them. By means of a small metallic disk and wires, rotatory movements of various velocity and direction were produced in the

spherical globules of oil thus suspended in water; making them to assume many conditions closely allied to planetary configuration;—to become spheroids flattened at the poles;—to throw off smaller globules having movements both of revolution and rotation;—and even rings like those which Saturn shows to our telescopes. These experiments, repeated by Faraday and others, are as valid in the way of inference as they would be were the scale of operation a million times greater. And the same may be said of the second instance we have before us, in those beautiful instruments and inventions of Foucault, Wheatstone, Piazzi Smyth, &c., illustrating the principle of the stability and composition of rotatory motions, and thereby expounding with admirable simplicity the great phenomena of the precession of the equinoxes, and of the earth's rotation on its axis. The *gyroscope* of Foucault set into action, and placed on a table, shows to the eye in a few minutes, by the angular deviation from its plane of rotation, the movement the earth has made in this short space of time;—a demonstration almost startling from its simplicity and grandeur. Under the miniature form, almost of a toy, this instrument beautifully illustrates some of the greatest phenomena of the universe.

We have lingered on the subject of astronomy, partly from the striking example it affords of the spirit and aims of modern science; partly from the speciality of its objects, as detached by distance from those relations which so closely connect the sciences treating of matter on our own globe. But though thus distant in space, the vast masses moving in the heavens, and especially the Sun, are variously associated with the matter of the earth, through the elementary forces, if we may thus term them, of which we have already so largely spoken. Here indeed we come again into contact with those arduous questions, where mathematical aids are scantily supplied and few certainties yet attained; but where

new facts and presumptions unceasingly offer themselves, the foundation and materials of more exact knowledge. Omitting gravitation, which we have already denoted as a special power in the material universe, there comes that wonderful element of Light; blending itself, as we have seen, with heat, electricity, magnetism, and chemical affinity, in such close co-relation of action that we can scarcely dissever its continuity, or detach these physical forces from connection with that great source whence light itself chiefly emanates. The solar beam, as unfolded and analysed in the spectrum, is in truth the most marvellous and mysterious object of the physical world; comprising in itself whole volumes of science, and problems that might put to trial the boldest theorist. The poetry of Milton, sublime though it be, fails to reach the reality of these great attributes of light, as evolved from a single beam, by simple refraction in passing through a glass prism. It is an analysis of exquisite order and perfection; in which not only are the several colours separated in the same constant proportions, with the intervention of numerous dark lines equally constant in their character; but rays of heat and of chemical power appear severally also at opposite extremities of the spectrum, partially interblended with those of colour, but in greatest intensity beyond the visible coloured limits of the spectrum. We are now speaking only of the simplest relations of the solar light to terrestrial matter; and without any immediate reference to the phenomena included under the undulatory theory of light, which, though attested by mathematicians, and interpreted by numbers, wholly transcend the powers of human conception. We allude, but cannot here do more than allude, to those formulæ of space and time expressing the amplitude and frequency of the undulations, and their variations for the several colours and rays of the spectrum; and the whole series of phenomena of transmission, refraction, polarisation, and interference of

light —discoveries which have given or added lustre to the names of Young, Malus, Fresnel, Arago, Brewster, Wheatstone, Hamilton, and others scarcely less eminent in this enquiry.

A word or two we must add here as to one relation — simple in fact, but not familiar to thought — which light establishes between man and the universe around. The total science of astronomy belongs in origin to this element alone. Extinguish those vivid points or bright surfaces of light which give splendour to the midnight sky;—deprive the astronomer of the feebler rays and fainter gleams which stars and nebulæ, invisible to the eye, bring before his telescope; —and you annihilate at once that science which can predict eclipses centuries beforehand; determine the orbits and return of comets; measure the distances of the fixed stars, and the motion of our own sun and solar system in the universe of space; and penetrate into systems of worlds beyond, where relative degrees of light become the solitary evidence of form and distance. Nowhere are these relations of astronomy to light so well illustrated as in Arago's 'Analysis of the Life and Labours of the elder Herschel,' recently republished in the collection of his works.

Other relations still remain to be noticed here. The phenomena of polarisation, as discovered on the earth, have carried our knowledge nearer to the fountains of this great elemental power; confirming Sir W. Herschel's opinion that light issues, not from the body of the sun, but from a luminous envelope, or photosphere around it. Yet further, the astronomer is able to show, by placing a prism before the object-glass of his telescope, that the light from the fixed stars is submitted to the same refraction, evolves the same colours, and possesses the same velocity as that of the sun, thus more explicitly denoting the sun itself as a simple star in the vast sidereal system. Even the new science of photo-

graphy furnishes examples of the relations we are indicating. Experiments show *qualitative* as well as *quantitative* differences in the chemical effects of light here produced; some of which we may attribute to the terrestrial media through which the rays pass; while others can hardly be explained but by supposing differences in the solar light at its very source, depending on the substance, configuration, or other conditions of the sun itself. The singular changes, periodical or otherwise, ever observable on the surface of this great globe, warrant the belief in such fluctuations of its light, though they may not yet tell us anything beyond this.

But we have yet to speak of other discoveries more recent in date, and illustrating, even more strikingly, these wonderful relations of distant worlds. We allude to those researches of Bunsen and Kirchhoff, which have just established a new method of analysis for metallic bodies — incomparably more simple, delicate, and perfect than any before known to us — through the coloured bands, severally produced in the spectrum by flames, in which infinitesimally small quantities of these metals are present. We have not space here to dilate on these remarkable discoveries, anticipated in some part by the researches of Plücker, Wheatstone, and other labourers in this field; but now well defined and opening a spacious path to further enquiry. They have already brought to our knowledge two metals before utterly unknown; and have shown others to exist where their presence had been wholly unsuspected. But the main achievement here is one which forms another link between the earth and its great luminary. By methods of research, equally ingenious and beautiful (founded primarily on the exact coincidence of the coloured bands from the metals with certain of the dark lines of the spectrum, but confirmed by evidence of still higher kind), these philosophers have proved the existence, in the photosphere of the Sun, of *six metals* at least, familiar to us on

the surface of our own globe; with the strong presumption that the same methods will multiply these or other analogous results. Discovery of this kind cannot lie dormant, and is indeed already pressing forwards. It is prolific of present inferences, and of promise for the future; and affords the best illustration of that progress and spirit of physical science, which it is our especial object to describe.

Having dwelt thus long on solar light, we may speak more briefly of that other form of elemental force, the Solar Heat, if indeed we can define this as distinct from the former, with which it is so closely blended in passing through space. Endless questions press upon us here, and discovery resolves one only to bring others into view. We have obtained innumerable facts regarding Heat in its various forms, and yet are ignorant of its intimate nature or even existence, apart from the matter by which its action is expressed. In all these questions we have still continually before us the abstract conception of forces or powers, acting in constant relation to each other in the material world — a relation capable in every case of being *numerically* expressed. The phenomena of light and heat stand peculiarly in this close connection, both in their origin in the Sun, and in all their secondary relations. We may seemingly separate the elements thus named by the intervention of certain kinds of matter, as in the familiar example of the glass screen, or in Melloni's more delicate and complex experiments. But such separation really tells us little more than does the disseverment of light into different colours by refraction through a prism; while all recent enquiries, especially those of Forbes and Melloni, have shown us that radiant heat, in common with light, is strictly subject to those great physical laws which are recognised as the basis of the undulatory theory; the connection being such that heat has not only been polarised and depolarised, according to the terms of this theory, but the phenomena of

circular and elliptic polarisation have still further confirmed and defined the analogy in question.

The evidences connecting electricity and magnetism, as forces, with the Sun and other bodies of our system, are different and inferior to those which establish the relations of light. Yet are they now continually becoming more numerous and significant. Whoever has seen the star of pure and intense light which bursts forth on the approach of the charcoal points completing the circle of a voltaic battery, or the *flood of light* thence poured by reflection over wide and distant spaces, cannot but suspect that the new 'fountain' thus opened to the eyes of men (and certainly not destined to remain an idle and valueless gift of science) may be the same in source and qualities as that higher fountain which diffuses light and heat over the whole planetary system. Sir J. Herschel, who ever makes his highest speculations subordinate to cautious induction, has assigned strong reasons for believing the Sun to be in a constantly excited electrical state. The singular phenomena of the tails of comets, he considers as only to be explained by supposing a *repulsive force* acting from the central body, which force electricity alone could furnish. 'The sun electrically charged would induce opposite states in the two hemispheres of day and night on the earth,' is the expression he applies to the effect of such solar condition upon our own globe.* And if we suppose, as may fairly be done, variations in the intensity of this electrical state, we acquire a probable cause for many periodical or secular variations which have hitherto embarrassed science. We allude here especially to changes in the intensity, declination, and inclination of the magnetic force—that extraor-

* These passages will be found in Sir J. Herschel's volume on the 'Nebulæ and Double Stars of the Southern Hemisphere;' a volume in which the tabular results of his vast labours of observation are intermingled with some of the highest speculations to which the human mind has yet *legitimately* reached.

dinary power which we are now taught to refer to particular conditions of electricity, in its connection with material media. General Sabine, whom the labours of a life have rendered our highest authority on terrestrial magnetism, has recently furnished evidence, from the exact coincidence in time of magnetic changes or disturbances at remote parts of the globe, that these are due to *causes from without*, irrespective of local conditions of the earth or atmosphere; while in pointing out the correspondence of certain periodical variations with the several conditions of the Sun, he has shown a direct magnetic relation between bodies thus distant in space. Diurnal or annual changes, subject to this relation, we may in part comprehend; but it needs new elements of knowledge to link together in theory, as General Sabine and Schwabe have seemingly done in fact, the maxima and minima of magnetic variation, with the greater or smaller number of dark spots present on the sun's surface; — a coincidence expressed, on present proof, by periods of ten to eleven years; but one so extraordinary in character, that we are bound to await other periodical recurrences before finally admitting it into the records of discovery.

Meanwhile the Moon also has been found, by delicate observations and averages carefully collected, to exercise a magnetic influence on the earth; — the needle expressing to the human eye certain small variations which strictly correspond with the lunar hour angle. This fact has its peculiar interest in suggesting, and with much probability, a similar influence throughout the whole planetary system, and possibly far beyond. The magnetic conditions and changes of the earth itself come into direct testimony here; — so general and strictly coincident over its surface, as to make it certain that the total globe is in a definite magnetic state; and capable through this state of affecting other worlds, as well

as the little needle which man makes his index of this mysterious force.

From these vast and remote actions in space around us, we come to those affecting the matter, whether inorganic or living, of the earth on which we dwell. The same great physical forces are still in unceasing action here; with more diversity of effect from the differences of the material acted upon, and from the reflected influence of organic life upon the matter out of which it is engendered. We have already spoken of the impossibility of giving more than a glance over this wide field; but even such cursory view will suffice to show the magnitude of the objects attained in each science, and the energy which is ever active to forward the work: — *τὰ ἡμίεργα ἐς τέλος ἐξεργάζεσθαι.* On one subject, indeed, that of Electricity, though beyond any other prolific of great discoveries, we need say little here, having in a recent review of M. De la Rive's work described its progress, and the wonderful results thence obtained, as well for pure science as for the practical uses of man. Yet even amidst these marvels of human attainment, it must needs be avowed that on certain points we are still in the very alphabet of Electrical science. The terms of *positive* and *negative*, though required for practical use and illustration, are little better than barren phrases as regards any perfect theory of the two polarities; while the whole subject of *induction* and *conduction* is still awaiting more certain and complete conclusions than have yet been obtained. That induction is really a certain form of conduction, we have every reason from Faraday's researches to believe. But we have yet to learn what are the states of the molecules of matter which minister to these inconceivably rapid propagations of force?—what the circumstances which render some bodies scarcely capable of this conduction? — what, further, the material conditions which give

transmission to circuit-currents so vast in length, and in which the opposite polar forces are maintained even though half the circuit be made through solid earth? We can only refer these and other questions equally obscure, to the labours of a future time.

The researches and successes of our own day are the best augury for this future. Many recent discoveries, simple and limited in their origin, have become volumes of new knowledge in their progress. Such are, for instance, the discovery of Oersted, on which depends the whole science of Electro-magnetism; — the doctrine of Electrolysis, as finally established by Faraday, in strict fulfilment of the law of definite proportions; — the further discovery of Faraday, that all matter of whatsoever nature, solid, fluid, or gaseous, is affected in a determinate manner when placed within the sphere of lines of magnetic force; — and his contemporaneous discovery of the rotation of a beam of polarised light under the influence of magnetic force directed through glass of a certain texture; followed by those larger researches (in which Plücker and Tyndall have partaken) disclosing relations between magnetic force and the intimate structure of all crystalline bodies. Many similar instances might be given, but these will suffice for the purpose we have before us.

Some single and unexpected observation may, perchance, furnish hereafter a clue to the truths still desired; and in the beautiful experiments recorded in the Bakerian Lecture and other later papers of Mr. Gassiot, we willingly recognise one avenue through which such research may well be directed. No one can have witnessed the wonderful phenomena of *stratified light*, as seen in the luminous discharges of a voltaic battery or induction-coil, passing through vacuum tubes of different degrees of exhaustion, without noting in these phenomena the elements of future discovery. The relation of the luminous strata so produced to the electrodes

or poles of the circuit, and the still more curious influence upon this discharge *in vacuo* by a magnetic force acting from without, are facts which carry us deeply into that obscure part of physical science, towards which so many paths of enquiry are now laid open and eagerly pursued.

Scarcely less remarkable than the discoveries in Electrical and Magnetic science, are those which regard the material phenomena of Heat. We have already spoken of solar heat and its connection with light, as transmitted to us from the sun. It is difficult to separate this, even in theory, from the heat unceasingly generated or lost in the mutual actions and changes of all matters surrounding us on earth; and science is ever tending to annul such distinctions. The main problem before us, as regards both solar and terrestrial heat, is the intimate nature of Heat itself;—whether it be a separate element, or simply a state or condition of matter? The latter definition of it, as a specific mode of motion of material molecules, interchangeable with other modes of molecular motion, we believe to furnish the best interpretation of all the various phenomena; and even of those seeming anomalies of the radiation and focal concentration of cold, which impugned or perplexed all earlier theory. This view, now adopted by the most eminent naturalists, is every day receiving fresh illustrations. The most recent is that furnished by the beautiful experiments of Professor Tyndall, 'On the Absorption and Radiation of Heat by Gases and Vapours;'—a research, the results of which are not limited to this single object, but embrace conclusions stretching far beyond;—even to the distinction of *simple* and *compound* molecules, in determining the internal actions, as well as qualities, of the matter by which we are everywhere surrounded. We cannot do more than allude to the foreign labourers in this great field — Ampere, Fresnel,

Cauchy, Seebeck, Schönbein, &c.; whose researches give new access to those higher laws of force and motion which we have marked as the ultimate aim of all philosophy.

If seeking to denote briefly the most striking characteristic of modern science in its direction to Matter, we should name at once the principle of Molecular action, as now applied to physical research. Through this doctrine has been made man's deepest inroad into the secrets of the natural world. No single principle is so variously applicable: none has done so much to promote discovery, or to authenticate and give the form and force of law to the results obtained. And yet it may be said to have had a lawless origin, and to have been long the play of human phantasy under the garb of science. We cannot here travel back to those early speculations on atoms, which entered so largely into the staple of the ancient philosophy; and which the poetry of Lucretius has better consecrated to later times than the most subtle prose of the Greek philosophers. In every intermediate age, even the darkest, the atomic doctrine in one form or other has kept a certain hold on the minds of learned or speculative men; - a natural effect of the facility with which it lends itself to any hypothesis, however crude, regarding matter and material phenomena. It was reserved for our own time to render it at once the subject and instrument of legitimate science; the foundation of laws next to mathematical in scope and exactness, and the most powerful of all aids to ulterior research.

This great achievement (for such it is) we owe mainly to Chemistry; and to John Dalton, the Quaker chemist, more than to any one besides. Close approaches had been made before to the doctrine of *definite proportions*, as represented by the molecules of matter in their combinations. Such anticipations are recorded in the case of every great discovery. But Dalton (speedily seconded indeed by other great

chemists) first gave clear declaration to the principle; and illustrated its applications, mighty in their universality, with a simple sagacity belonging to the genius and habits of the man. The simplicity of his early experiments is, indeed, characteristic also of the manner in which many of the highest truths in science have been reached. Facts the most familiar to common observation, and thence disregarded by common intellects, have furnished better materials and suggestions for discovery than the most recondite theories.

It has been justly said by Sir J. Herschel that *number*, *weight*, and *measure* are the foundations of all exact science. The atomic doctrine has acquired from chemistry these conditions, which give it substance and certainty as a physical truth. When analysis and synthesis, carefully applied to compound bodies, disclosed a constant and definite proportion of the combining elements, and an equivalent or multiple ratio of parts in every chemical change, the requirements of number, and weight, and measure were all met and satisfied by the discovery.

Here then we have a great law, or group of laws, thoroughly attested; — of high generality; — and proving, because based upon it, that atomic or molecular constitution of matter which alone could afford such results. Whatever name we give to them, these atomic parts exist in all bodies, and determine by their own nature or arrangement the properties and functions of each. That they are minute beyond all human measure is proved, not only by the chemical relations just denoted, but also by those relations to heat, light, electricity, and mechanical force which experiment has demonstrated. No hindrance, indeed, to belief need exist on this score. Matter, either unorganised as we term it, or organised into life, affords endless examples of a divisibility, which we seek to put before the eye in figures, but which no human sense can follow or conceive. While,

however, even imagination utterly fails to reach the reality, reason accepts this next to infinite divisibility of matter, and the conception of polarities and mutual relations of atoms so constituted, as the sole method of expounding the phenomena. Such subtility of their elementary parts may fairly be stated as an *integral necessity* in the composition and changes of all the material bodies which surround us.

Had we room here, we might dwell on the astonishing results already derived from this new method of chemical enquiry, through the atomical combinations of matter; and those especially which bring new laws of action and combination into view; such as the doctrines of *isomorphism*, *atomic substitution*, *homologous series of compounds*, *compound radicals*, *catalysis*, &c., which we owe to the labour of Berzelius, Mitscherlich, Liebig, Hofmann, Brodie, and other chemists. Each one of these laws, thus based on the atomic doctrine, is a special example of that spirit of profound research which marks the science of our day; while the growth of organic chemistry, in sequel to labours pursued on this principle, is perhaps the most wonderful of the results thence attained. No surer test of truth in any law than its power of predicting events or effects yet unknown. When, for instance, we find in the different series of organic acids, where every step of change is made in multiple ratios of numerical exactness, that certain void places, left in the first construction of the series, are afterwards filled up by the discovery of compounds answering *precisely* to the numerical conditions required, we see at once how much has been done towards the deciphering of this secret scroll of nature. Had the mystical arithmetic of the Pythagoreans and Alexandrian Platonists been converted from a dreamy speculation into sober reality, it would have fallen short of the actual results which this part of science has disclosed to us.

But though especially demonstrated in chemical affinities,

the atomic theory is far from being limited in application to this single science. We have seen that the other great forces are known to us by their actions on and through matter, — such actions and changes, whether from light, heat, electricity, or dynamic force, giving foundation to the several sciences which bear these names. Co-related as they all are with chemical phenomena, we might expect some corresponding relation to that atomic constitution of bodies, from which modern chemistry has drawn its greatest discoveries. And accordingly we find numerous and striking proofs to this effect, furnished by those who are seeking to solve experimentally these high problems, and thereby to establish new connections in the sciences, and laws common to all. We may take as a most instructive example, the various and beautiful phenomena of crystalline bodies, in their relation to heat, light, and electricity. The crystal itself, whatever the matter composing it, must be regarded as a substance, the component molecules of which are compelled by a force or affinity (what we may *provisionally* call polarity) to assume certain definite positions, determining both the inner structure and outer form. The three forces just named all affect most curiously this molecular arrangement. Mitscherlich has shown that while octäedral crystals expand equally in all directions from heat, other crystals, not in this group, change the measure of their angles with every change of temperature. He has further shown that great alterations may be effected by heat in the internal structure of crystals (as in the case of certain prismatic crystals evolving octäedrons under exposure to the sun's heat), without affecting their solidity or altering their external form. The geometry of crystals, indeed, we may fairly say, is but the *outer side* of the science; the atomic relations and changes *within* put other and deeper considerations before us.

The fact, now attested in so many ways, that molecular

changes, transient or permanent, may occur within all bodies while retaining what we call their solid state, is one of high interest, and not enough regarded in its application to every part of physics. The familiarity of some of the instances disguises what is most curious and important in their nature. The simple expansion of a metallic bar by heat involves an atomic change through its every part; less complex, it may be, than those changes of molecular arrangement within crystals which affect the passage of light through them; but analogous in the main fact of the mobility of atoms, and their power of assuming new and definite position within what we call a solid body. We know from recent experiments that an iron bar is sensibly elongated, and the elasticity of iron transiently, of steel permanently, altered by magnetisation. We know further that the capacity of iron to conduct heat is variously modified under the electro-magnetic action. We have the certainty, from the effects manifested at its extremities, that every molecule in the wire of an electric telegraph, whatever its length, undergoes change at the moments of transmission or cessation of the electric force. Without stopping to enquire whether such internal changes may not be interpreted as a *tendency* to what we term fluidity, we clearly see in them a proof of the *individuality of atoms*; and very strong evidence that these molecules of matter, minute beyond conception though they be, are endowed individually with axes of motion or polarities, determining their mutual relations, and the changes they undergo when submitted to forces from without. Such conclusions, forced upon us by the simplest view of the subject, are strikingly corroborated by the whole course of modern enquiry; and very especially in those sciences which have their foundation in the actions of light, and the electrical and magnetic forces, upon matter. The time may come when molecular forces or affinities, now represented chiefly in chemical

actions, may be reduced to a common principle with what we term *mechanical forces*. And if gravitation be ever submitted to some common law with other powers, such law will probably be founded on the nature and functions of these ultimate particles, — the *σώματα ἀδιαίρετα* of ancient philosophy,— the materials on which modern science works, amidst the most profound mysteries of the natural world.

The whole science and exquisite art of photography, in the relations it establishes between light and molecular changes, gives further evidence that these changes form what may justly be deemed the *substratum* of all physical knowledge. And the same inference is derived from the discovery of what have been called *allotropic* states of various substances, as phosphorus, oxygen, &c.; where an entire change of physical properties is produced, the matter so changed retaining, as far as experiment can tell us, its exact identity of nature. The supposition of an altered arrangement of similar constituent atoms, is the sole present method of explaining this curious phenomenon.

We name these few instances out of many equally remarkable; all expounding, in one form or other, the great principle of molecular action and relation, to the clear conception of which modern science owes so much of its success. Even the points still open to controversy — such as the true nature of the distinction between para-magnetic and dia-magnetic bodies (those which take position parallel to the line of magnetic force, or transversely to it) — are clearly seen to depend for solution on more exact knowledge of the modes of molecular aggregation, and their influence on the forces which traverse them. Again, we have the question before noticed, as to the phenomena of the electrical induction through air, glass, and other media; — whether these are due to physical causes yet unknown? or to molecular polarities

and motions, far removed from all cognisance of the senses, but interpreted to our reason by the closest experimental analogies? Faraday has given the sanction of his opinion to the molecular view of the phenomena, and Grove and others have done much to strengthen this conclusion.

We have hitherto been speaking of Matter generally, without regard to the various aspects under which it is known to us. For with all the refinements of modern analysis, there still remain more than sixty substances *undecomposed*, and which must therefore be deemed simple or elementary to our present knowledge. Of these the largest proportion are what we term metallic bodies, and most of the additions recently made to the list of simple substances belong to this class; with the further curious speciality pertaining to several of them, that, while perfectly distinct from all others in physical characters, they are hitherto known to exist in a few rare specimens only. Almost we might be tempted to surmise that they belong to the number of those materials of which aerolites seem to tell us that other worlds are made; and that they exist more largely in these worlds than in the feeble representation of their existence on our own globe. Such suggestion, however, must be received simply as illustrating the manner in which modern science attaches facts already attained to problems yet unresolved; concentrating them as it were around common *foci*, towards which they ever more closely converge.

The great problem regarding these many kinds of matter on our own earth, lies in the question, whether they may not hereafter be lessened in number by reduction to certain elements, common to several or all? Whether, in other words, bodies simple to our present knowledge, are not actually compound in their nature? Chemistry, it must be owned, has hitherto done little directly towards solving this question;

the vast resources of analysis having tended to multiply elements upon us, rather than to abridge their number. Some approach in this direction has, however, been made through the law of isomorphism; which, in showing relations of mutual substitution between certain elementary bodies having other curious resemblance of physical properties, has led to their arrangement in groups; preparatory, it may be hoped, to some future discovery which will give a common basis to all the bodies thus related. The most remarkable of these groups is that comprising chlorine, iodine, and bromine. Arsenic and phosphorus — selenium and sulphur — and the group of the platinum metals, are other examples of these singular relations, to which, in connection with the law of definite proportions, the labours of the chemist are sedulously directed; not solely for instant results, but with the prospect constantly before him of those higher truths, to which some one single discovery may perchance open the way. The present methods of chemical enquiry are peculiarly fitted to this *critical examination* of the simple bodies; while in the spectrum analysis — that extraordinary discovery of which we have spoken — we find the promise of results scarcely yet compassed even by the imagination. Electricity, again, equally powerful and delicate as an instrument of research, has been, and must ever be, an especial aid in the prosecution of an object worthy of all the labour that can be given to its attainment.

We have already spoken at some length, of Light as an element in the universe; and of its properties as it comes transmitted to us from the Sun and other worlds in space. But much more might be said, had we space for it, of those wonderful phenomena — whether derived from solar or artificial light — which have exercised the highest genius of modern science, and largely invoked mathematics as an aid to experimental enquiry. If we have not yet reached a true

and complete theory of the spectrum, or learnt the many conditions under which light penetrates, pervades, or even becomes latent in different forms of matter, this deficiency is due, not to any want of zeal in research, but to the intrinsic difficulties of dealing with this subtle and multiform element. Looking at the colours alone of the spectrum — so beautifully defined to the eye by the several refrangibilities which evolve them — controversies still exist as to the manner in which they combine with each other; and until the recent suggestion of Sir J. Herschel, followed by the very valuable researches of Professor Maxwell (1861), which rescue green from its subordinate place as a compound of yellow and blue, we were at fault even as to what might be deemed the primary colours in the scale. The connections of another portion of the spectrum, with those changes in the molecular conditions of matter which we call chemical, furnish a new avenue to the higher physical laws which lie before us. In photography, the exponent of these changes, we have an agent so working as almost to put to shame the manipulations of human art. To fix what we transiently see by reflection from a mirror, was the object sought for, and for a long time ineffectually. Once attained, every year has added to the beauty and perfection of an art, which may especially be called the child of science, and which we must not yet affirm to have reached its maturity. Whoever gazes on the colours of the solar spectrum, cannot but be seduced into thinking that photographic chemistry may hereafter afford colouring to our pictures, as well as the simple imagery of light and shade. We are still too imperfectly acquainted with the complex machinery of the solar beam to warrant abandonment of the object; even were it not probable that the phenomena of colour are mainly due to the atomical constitution of the bodies recipient of light, and to the organic structure of the eye itself, forming the last material link with

the percipient being.* This, in truth, is one of the cases now frequent in science, where even failure may become a fountain of discovery. Negative conclusions have their value as well as positive ones, and often form an index to the path through which truth and certainty are finally reached.

Without going into details, we may allude here to the recent photo-chemical researches of Bunsen and Roscoe; to those of Becquerel on phosphorescent and fluorescent bodies; and, still more, to the remarkable experiments of St. Victor and Grove; all showing the direct action of light upon the molecules of matter to be far more universal and minute, as well as more definite and lasting, than was before dreamt of in our philosophy. In man, it has been the general presumption that light finds ingress by the eye alone, and with the sole effect of giving instant vision of things without. But recent enquiry calls upon us to recognise, even in the eye itself, the *retention* and probably *reflex actions* of light within the precincts of the organ; affording, through what we may venture to call photographic impressions on the retina, the only plausible explanation of its *subjective functions*, and of other phenomena little heeded from their familiarity, but presenting problems of the highest interest to philosophy. The experiments of D'Arcy prove that the impression of light is often retained on the retina for fully two and a half minutes, — the time in which a luminous particle or undulation passes through nearly thirty millions of miles of space! What is the condition of Light — be it conceived as matter, or motion, or force — when thus arrested and enchained in a living organisation? In this brief question lies one of the most profound

* The curious phenomena of *colour-blindness* afford illustration of this remark. This subject is treated of by Sir J. Herschel in a recent Memoir; in which also, with his wonted ability, he revises generally the mutual relations of the prismatic colours, and presses upon the notice of the experimentalist the important distinction between the study of pigments or negative colours, and prismatic or positive ones.

of the problems to which we have just adverted. The older theory which regards light as an emission of material particles, was called upon to answer the enquiry, what becomes of *matter* thus absorbed? — while the undulatory theory, now accepted as the great law of Light, has to explain what becomes of *motion*? In the latter theory, closely linked as it is with the doctrine of convertible forces, we undoubtedly find the easier solution of the problem. But in this part of science more especially, such questions are perpetually pressing upon us, each fresh fact (and the simplest are often the most suggestive) giving access to objects of more advanced thought and speculation.

In passing thus cursorily over the sciences which deal with the various forms of matter on our globe, and the forces affecting them, we have said nothing of that Science now become so vast in its objects and methods, which takes as its province the outer structure of the globe itself; and the changes, organic as well as merely material, succeeding one another for ages on that surface which is now the dwelling-place of man. Such seeming omission we may explain by reference to previous Articles of this Review, in which the present aspect of geological science, and the questions it involves, have been considered at some length. In no one department of Natural knowledge, we may safely affirm, has greater zeal and activity been displayed, or with larger and more successful results. We must repeat further that Geology has (within the last thirty years more especially) undergone a change which raises it far above the mere history of the succession, location, or dislocation of strata, and connects it inseparably with other branches of science still more fruitful of discovery. Fossil Geology in particular, the creation of our own time, affords a striking example of what may be attained by zealous research, submitted to

methods of sound and careful induction. This science has given us deeper insight into the natural history of our globe than any other can supply; and, taking order of succession as its basis of enquiry, has furnished more certain means, through fossil remains, of identifying strata in distant parts of the earth's surface, and what is a far higher attainment, of determining the forms of organic life, during ages long anterior to all human calculation of time. This is not merely a new branch of knowledge, but almost an ingress into a new world. Nor can it in any sense be deemed a stationary science; while vast regions still remain wholly unexplored; and while occupied, as it continually is, not solely in discovering new fossil species, but with the higher object of determining the origin and succession, in the series of rocks, of those typical forms of life which have descended to the Fauna and Flora of our own day.

This subject of Palæontology is indeed allied in every part with the present history and physiology of animal and vegetable life; that great domain of knowledge which, though closely encircled round by physical laws and phenomena, and approached only through these, has still a secret region within, — the origin and principle of life itself, — hitherto inaccessible by any method of human enquiry. It was our design to have included Physiology among the several subjects of this article; as illustrating not less than other branches of science — in some points even more strikingly — the advances made in actual knowledge, and the spirit which impels and animates to further research. While admitting that this spirit has sometimes run riot upon questions, the very mystery of which invites and emboldens speculation, we find true inductive science moving steadily onwards amidst these more erratic courses, to those truths — the κτῆμα ἐς ἀεί — which are the certain reward of all legitimate inquiry. So much, however, has recently been

attained in animal and vegetable physiology at large, and very especially in the great department of Human Physiology, that not even the briefest summary could bring the subject within our present limits; and we must postpone to another time the notice of these eminent discoveries, and of the works which best describe and illustrate them.

What has been derived, however, from other branches of physical science will, we trust, adequately fulfill our intention of showing in what spirit all such science has been recently pursued; and what signal success it has obtained in compassing and expounding the great phenomena of the natural world. Happy those who can work tranquilly amidst these wonders of nature, animated by the love of knowledge for its own sake, and undisturbed by the storms which are ever agitating and vexing the world without.*

* It is always interesting as well as important, to learn the different methods by which men of genius arrive at a common truth. When the first edition of this volume was published, I knew but by name only the remarkable writings of Dr Mayer of Heilbronn (appearing under various dates from 1842 to 1851), who, by the doctrine of the mutual convertibility of certain of the physical forces as maintained by bold and ingenious argument, anticipating in part the experimental proofs which have now given it the character of a great physical law. His earlier views chiefly appertain to the equivalent relations of Heat and Mechanical Force: but in later memoirs he extends his argument to other forces including those which act in the phenomena of organic life.

LIFE AND ORGANISATION.*

[Edinburgh Review, January 1859.]

IN a former number of this Review (Jan. 1858), we took occasion, from some remarkable works then before us, to comment on those present conditions of physical science which more especially mark its progress onwards, and the larger scope and higher spirit now given to its pursuit. Our view, however, was then confined almost exclusively to the inorganic part of creation; to those sciences which treat of matter unendowed with life, and of the great natural forces or powers which we recognise by, and through, their various action on the material world.

We have now before us another series of works (to which many more might be added) recording the present state of our knowledge of matter organised into life; of that vast domain of animal and vegetable existence which lies around us; presenting a thousand problems to our reason, and almost appalling contemplation by the multitude of its objects. This short and seemingly simple word *Life* does, in truth, in

* 1. *General Outlines of the Organisation of the Animal Kingdom, and Manual of Comparative Anatomy.* By Thomas Rymer Jones, F.R.S. (Second Edition.) London, 1855.

2. *On Parthenogenesis, or the Successive Production of Procreating Individuals from a Single Ovum, from the Hunterian Lectures on Generation and Development for the Year 1849.* By Richard Owen, F.R.S., &c. London, 1849.

3. *The Rambles of a Naturalist on the Coasts of France, Spain, and Sicily.* By A. de Quatrefages. 2 vols. 1857.

4. *Sea-side Studies at Ilfracombe, Tenby, the Scilly Isles, and Jersey.* By George H. Lewes. 1858.

5. *The Master-Builder's Plan, or the Principles of Organic Architecture, as indicated in the Typical Forms of Animals.* By George Ogilvie, M.D. 1858.

itself include the greatest of all the problems submitted to human thought. All distinctions and diversities are trifling in comparison with the one line, which separates inanimate matter from those living organisms created out of it; with properties and powers of endless variety; and, above all, endowed with that wonderful power of reproduction, which maintains the continuity of the species while individual forms are successively passing away. No step so vast as this, no mutation so wonderful, in any part of creation. The mystery is not solved — scarcely lessened to our conception — by those researches which, descending in the scale of existence, seem to obliterate all certain distinction between animal and vegetable life, and to bring the latter to the very lowest grade to which the term *living* can fitly be applied. It is still the distinction between that which can reproduce itself and that which cannot; and in this single condition lies the clearest expression of all vitality, whatsoever its form or degree. No definition of life can be complete without it. Alone it suffices to mark that line of division which even the finest microscope fails to reach; and it applies no less to that more wonderful and complex animal machinery by which the higher forms of existence are maintained and perpetuated.

Into this domain of organic life modern science has penetrated with not less zeal and success than have signalised it in the other branches of physical science, notwithstanding certain distinctions which may seem to favour the pursuit of the latter. Such are the surpassing grandeur of the various discoveries in inorganic nature; — the mathematical certainty of many of the laws thence derived; — and the important practical uses to which these discoveries have been applied, enlarging the dominion of man over nature through elements which were formerly known but as objects of admiration or terror. No period has been so prolific of these achievements as that in which we are now living.

On the other side, however, we find numerous incentives to a like zeal in the study of the living existences around us. The simple presence of the attribute of life, as we have denoted it, tells for much with every reflecting mind. But this part of natural science gains also by the comparative facility with which it may be successfully pursued. Few can compass all that is required for experimental research, especially under those refinements of method which have now become essential to success. Many are competent to a science chiefly of observation; amidst objects present to the senses, often associated with the charm of natural scenery, and consonant to the natural tastes and habits of the mind. The traveller who gathers his unknown plant in Australia or Paraguay; the naturalist who discovers some new form of animal life, or disentombs some fossil from its rocky sepulchre of ages; the physiologist who detects new organs or instincts in animals already known — all hold rank, in one degree or other, as labourers in this great field. No fact so small as not to find a place in the volume of natural knowledge.

In thus distinguishing, however, the two great objects of scientific pursuit, it must be kept in mind that no strict line of demarcation exists between them. The progress of knowledge is ever bringing more closely together, and under the dominion of common laws, facts and phenomena apparently the most remote. Though rejecting the modern phrase of 'unity of science' as a vague effort of language to reach an ambiguous truth, we see and admit a constant propensity towards unity in a more qualified sense. Facts multiply every day in number, but every day they are submitted to new conditions of order and comparison. Phenomena familiar to the senses from the earliest ages of human records, are expounded to the reason by the discoveries of our own time. Life itself, taking the term in its simplest sense, can be interpreted only by the laws which pervade all matter; and is

unceasingly subject to those great elementary forces — gravitation, heat, light, electricity, and chemical action — which are ever in operation around us. They are the instruments in those wonderful organisations which it has been the will of the Creator to bring into being; and they have subordinately become instruments in our hands for interpreting these higher manifestations of the creative power.

It would be impossible within the limits of this article to analyse the several works prefixed to it, or even to denote the especial objects and merits of each. It will be seen that several of them relate more especially to those lower forms of animal life which lie close to the boundary — if certain boundary there be — between the animal and vegetable world. This particular portion of natural history has of late risen into high popularity, and the works devoted to it display an exuberant enthusiasm in the research. While the astronomer is soberly dealing with the great elements of space and time, which make the material of his science, the modern naturalist is noting in rapturous language about the beauty of his zoophytes, and the microscopic marvels of infusorial life. The real beauty of many of the objects, the scenery with which they are often associated, and the curiously delicate methods of research employed, will explain in some part this ardour of pursuit. Nor can we deny a sentiment of grandeur as belonging to objects even thus minute, when so infinite in number and variety. That which human calculation cannot reach, has in itself a certain element of the sublime, be the subject what it may. But, connected with this study, we have also the many mysterious questions which regard the manner of generation and existence of these simpler forms of animal life, and their relation to other beings of higher order; — topics well fitted to take strong hold on the mind of every thoughtful man.

On some of these questions we shall have to speak hereafter.

Meanwhile, we must explain in reference to the subject of this article, that although we have it in view to indicate the progress and spirit of modern science in its researches into organic nature, we must limit ourselves mainly to Animal life; referring to that of the vegetable world only in illustration of the former. Even under this limitation we cannot go into anything like a complete review of the topics embraced under the name of Animal Physiology. Whoever takes up the massive volume of Dr. Carpenter — a work of great excellence, and the most complete we possess — will see how much is comprised in this wide domain, how profound the subjects offered to human thought, how large the voids yet left for future enquiry. What we may reasonably attempt, is to place before our readers a summary view of such questions and discoveries in this part of science as are of highest import in themselves, and best indicative of the scope and spirit now given to its pursuit.

It will be obvious, even to those who give only casual thought to these questions, that many of them tend to take a metaphysical form; while not a few are of a nature wholly to transcend the present faculties of man. The attainments actually made by these faculties, in their more exalted use, furnish reasons for not drawing hasty and arbitrary lines in limitation of further progress. But certain barriers there are which the highest genius is the first to recognise and submit to; seductive though the speculations may be which here first press upon the reason. Not less boldness and mental power are shown in well defining the boundary of research, than in adventuring wantonly over and beyond it.

What we have already said on the abstract principle of Life, as appended to material organisation, will show that this, the great and elementary point with which we are here concerned, comes under the class of questions just spoken of. Notwithstanding all that has been done — and it is vast in amount

and variety — towards our knowledge of living beings, and of those organisations upon which vital functions depend and by which they are maintained and reproduced, the question unceasingly recurs, and can in no way be put aside; — What is the principle or property — if any — superadded to the known properties of matter, giving it those new conditions which create and constitute vitality? It is this enquiry which, in one form or other, has exercised every age and school of philosophy; and been argued the more intently, or even passionately, from the question having been often made to embrace intelligence and the other mental functions, as well as mere vitality. Under this latter aspect, it will be recognised as that old problem of Materialism, upon which so much argument has been wasted; — a controversy equally fruitless in all time to come, since no human conception can reach the abstract nature either of matter or mind; nor any argument show that things perceived by the senses have more independent reality than the principle perceiving, and the intelligence and volition acting upon them. The materialist fancies himself on firm ground, because his argument has Matter for its foundation. His matter itself is known only by and through that mind which he assumes to create out of it.

On this point, and for these reasons, we do not dwell longer; but rather proceed to that part of the subject, more accessible to human reason, which engages at this time the earnest attention of naturalists in every branch of their science; viz., the manner and extent of influence of the great physical forces ever in action around us, in producing and maintaining those other powers and properties which we call *Vital*; and which, in their aggregate, represent all we can define as Life upon the globe. It is clear that these great powers, Heat, Light, Electricity, and Chemical force or affinity, whatever their nature or mode of developement, stand to each other, in their action on matter, in the relation of

mutual convertibility; — that their forces, however altered in respect of action, are never really lost or lessened; — that they are the efficient energy, not solely in the greater and more obvious phenomena of the material world, but equally so in the most minute molecular actions to which matter is subject. We can modify, by human powers and machinery, the aspects of force and its actions upon matter. We can never either create or annihilate it. These conclusions, at the utmost but vaguely and partially surmised before, have now acquired certainty enough to give them place among the great general laws of nature; and experimental science is every day bringing fresh facts to their proof and illustration. Whether the term of 'Co-relation of Forces,' provisionally applied by Mr. Grove to describe what is our present knowledge, may not hereafter merge in the single phrase and conception of *Force*, as contradistinguished from the matter on which it acts, is a point open to future determination. Mutual convertibility is closely akin to unity, if not an actual expression of it. Much that is of the deepest interest to philosophy hangs upon the solution of this problem; involving, as will be seen, all the relations of matter to that mighty influence which has been destined to mould it into form, activity, and even into life itself.

It is here, in fact, that we find ourselves in the very heart of the question to which we have just alluded as still the subject of serious controversy; viz., whether there be really any separate Vital Principle; a positive and independent power, giving organisation and life to certain combinations of matter?—Or whether the simple vital phenomena may not be referred, as effects, to those great physical powers, which we see acting so incessantly on all matter in the universe; and the actual influence of which upon the vital functions is obvious at every moment of existence?

Each of these views has found zealous advocates, and been

discussed in the bold and free spirit which belongs to the science of our day. Each, in truth, furnishes ample materials for difference and dispute. Looking at the controversy as it now stands, we find the latter opinion to have gained much upon its adversary. The doctrine of an independent vital principle is one of old date; and in its very nature admits of little argument or advance. It rests mainly on the assumption that the phenomena of life, even in their simplest form and apart from mind and intelligence, are unlike, and incongruous with, any actions of which we are cognisant as the obvious results of physical forces operating upon matter. Though the argument may be varied in form, yet in no way can it be made more absolute, or stretched beyond this method and degree of proof. By the very terms of the question, we quit here the region of the senses and of material experiment, and affirm a power unknown, except in what we presume to be its effects. It is negative evidence; and, as far as we see, can never be rendered other than such.

Those who advocate the other view, adopt a doctrine equally insusceptible, it may be, of positive proof; but yet constantly progressive, and in its progress prolific of results favourable to the conclusion sought for. They have the advantage in the very outset of being able to affirm, that without the action and influence of the physical powers in question, no life could possibly exist. The wonderful discoveries recently made as to those more subtle actions of electricity, heat, and light, which evaded the grosser experiments of former times, have assisted their argument. Equally so the researches, not less wonderful, into the molecular constitution of bodies; and the relative proportions in which such molecules, whatever their nature, unite in every case of chemical combination. Chemistry, in fact, and especially the chemistry of organic bodies, has done more for us in deciphering the structure and functions which appertain to life, than any of the other

powers of physical analysis. The definite proportions which exist in every union of the simpler chemical elements, are found also in the most complex compounds which form the material of living bodies. The poisonous ingredients of animals and plants, equally with their nutritive portions, yield invariable results to organic analysis. Various specific secretions familiar to us in the human economy, exist, under the same chemical composition, in the lower animals, even as far down as insect life. A minute quantity of phosphorus is detected in the nervous substance of the brain, bearing a certain proportion to the other ingredients, and showing thereby its determinate relation to this wonderful part of the living economy. Endless similar instances might be given, to prove the extent and uniformity of the chemical actions which pervade every living texture; equally definite in all which concerns its growth and maturity, as in the changes which precede and produce its final decay.

But modern Chemistry goes yet further in its aims and success. Numerous substances, both animal and vegetable in kind, known to us before only as the products of living actions, have been actually produced in the laboratory; identical in every chemical character, but subject, we must add, to this notable distinction; that whereas in nature the series of living organisms is begun from the combination of a few simple elements, no present artifice of chemistry can fully imitate this higher workmanship, otherwise than by acting on compounds already formed. In theory, however, it does not seem improbable that this ultimate step may yet be made. Whatever experimental skill, aided by boldness of aim, can accomplish, will be done by those who now work in the physiological department of chemistry. The schools of Liebig, Dumas, Hofmann, Bernard, &c., are creating pupils and fostering a zeal in the pursuit, to which we may well look for results hitherto unimagined or unattained.

We may dwell somewhat further still on this argument of the relation of the great physical forces to vital phenomena, inasmuch as the question is really supreme among those which relate to the theory of life. It is obvious as a principle in conducting it, that we must proceed upwards from the lowest and simplest forms which occur in the scale of being. If in these the properties of life and reproduction depend on physical agents alone, without any new and unknown principle of power being added, we must needs carry the conclusion onwards to higher grades of organisation. No line of limitation exists, obvious either to the senses or to reason. Some might conjecture it to lie in the distinction between animal and vegetable life. But, even acquiescing in all that is expressed in this distinction, can we fairly claim for the Medusæ or the Oyster a peculiar cause or principle of life, which we deny to the Sensitive plant, the Dionæa Muscipula; or to the common Nettle, Berberry, and various other plants, each endowed with some peculiar sensibility or motive power? That the same natural forces have influence on all these organisms is certain. Are we to suppose some mysterious agent, yet unrecognised, as needed in addition to explain the appropriate functions of animal life, even in their simplest form of organisation?

This particular question is obviously subordinate to the larger one we are now discussing. The grounds of argument are the same, the difficulties exactly alike. Thus far we have dwelt more especially on chemical action, as giving us closest access to the laws of vitality. But Electricity, that wonderful agent on our own globe, and probably throughout all space — which, scarcely known a century ago, is now the most powerful instrument in the hands of man — bids fair to become an equal exponent of the vital functions, and especially of those important functions which belong to the nervous system. We shall have occasion to recur to this

point, and merely mention it here, as relating to one of those great powers which are incessantly acting upon and through life in all its forms. The same may be said of Heat; the influence of which, in promoting organisation and maintaining the vital functions, is familiar to us in a thousand ways, and attested in more scientific form in every part of animal physiology. The action of Light, as separate from heat, is somewhat more ambiguous; but that it has special effects on these functions cannot be doubted: and very remarkable proofs of this are every day multiplying upon us. We might almost deem sufficient as evidence, the spectacle of the sudden bursting forth of life of all kinds under the influence of a bright summer sunshine. But science goes far beyond this, in showing that Light, like Heat, does truly permeate and act upon those molecules of matter, of which all bodies, organic or inorganic, are composed. Much is yet to be learnt on this curious subject.

Such are the general evidences and arguments of those, who believe that we need look for no other vital principle than lies in some modified function of the great forces which we see in unceasing action around us, and feel to influence at every moment the conditions of our own being. The fact already noticed of their mutual convertibility, and other various proofs that force may be hidden, latent, or altered in aspect, but never effaced or lost, undoubtedly favour this view. When its sensible effects disappear, we have cause to believe that it is either operating in some way too minute for our detection, or that it exists in a latent condition ready for some new form of future developement. The advocates of this doctrine are apt to startle us by their bold illustrations. We feed a jaded horse on a peck of oats, and he is able to travel again; — the effect, say they, of the evolution and conversion into *nerve force*, of that power which has been laid up in the grain during its growth. We light and warm

ourselves, and give propulsion, to our engines, with that coal which for countless ages has retained within its substance the light and heat of its original forest growth. Such instances as these may seem rashly to outrun the cautious step of scientific induction. Yet they find authority in the fact, well authenticated by Faraday, that one drop of water contains, and may be made to evolve, as much electricity as under other manner of evolution would suffice to produce a lightning flash. And we might quote as an instance not less wonderful, and still more in point, that germ of vitality preserved for twenty or thirty centuries, which can make prolific, under our own eyes, seeds taken from the mummy cases of ancient Egypt. When positive observation teaches us this much, we are not in case to deny the analogous conditions put before us for belief. The abstract conception of *force*, thus laid up for future evolution under the same or a new form, is one of the most profound upon which either reason or imagination can dwell.

We must not, however, linger further on this question, fundamental though it be to all researches into the nature and laws of life; and blending itself with every subordinate question in which these laws are concerned. If it seem that we have pressed the argument too much on one side, we must repeat that the doctrine of a separate vital principle rests on negative grounds only, and little admits either of amplification or detail. The bold and active science of our day has for the most part ranged itself on the opposite side; and is ever occupied in fixing new relations and equivalents of power — the materials, it may be, of more general laws than have yet been reached by human intelligence.

The question we have been discussing is common both to animal and vegetable life. We now come to other topics, subordinate and more special in their nature, yet all of high interest to natural science, and all demonstrating the spirit

and zeal of modern enquiry. The first of these topics has been already partially noticed; viz., the relation to each other of these two great natural provinces, each so profusely peopled, and each exhibiting such wonderful design and exuberant variety of the creative power. This question has of late been closely examined by naturalists. It involves the fact, in itself one of great interest, that in the lowest and simplest forms both of animal and vegetable life, there is so close a coalescence of the two, as well in structure as in mode of developement, that it is often difficult to say to which the individual belongs. Even the acute microscope of Ehrenberg put down as Polygastric Infusoria what are now discovered to be germs of vegetable life. We are brought here, in fact, to that doctrine of our own time, that the *simple cell* is the primitive germ of all living organisation, even of that which in its end attains the highest grade of animal existence. On this subject we shall have to speak hereafter. Meanwhile, looking simply at the two great kingdoms of life, as they diverge from this initial point by a gradual scale of ascent to higher states of each, the special question arises; – What are the peculiar physical conditions which separate and severally distinguish them? Of the answers to this question all may be said to converge more or less towards one point; – viz., the fact, well established, that while vegetable life is created and supported from *unorganised* or *disorganised matter*, animal life always requires for its nutriment matter already organised either by its own or vegetable processes. It cannot, so to speak, work the raw material into its own texture. Even the mere animal jelly, floating in water without obvious organisation, is nourished by absorption of vegetable sporules, or animal matters so comminuted as to serve to this end. A more special distinction, but equally explicit, has been drawn from the chemical action of plants on the atmosphere. Expressing it in the words of Professor

Huxley, 'Wherever an organism is found to decompose carbonic acid under the influence of sunlight, and to set free oxygen, that organism may be ranked as a vegetable, however active may be its movements.' Others have been suggested (such, for instance, as the curious fact that no living being has a form *geometrically regular*, or shows other than a *curved configuration* of its surfaces): but none, hitherto adduced, are so striking or unequivocal as those to which we have just adverted.

We have before stated our design to limit the present article chiefly to those researches into Animal life which have been so prolific of discovery, as well as of speculation — often profound, sometimes rash — on this higher part of creation. The same reasons which lead to this limitation, will oblige us to take up these topics in a somewhat desultory manner; with less regard to their order and completeness, than to the interest they possess, or the illustrations they afford of the progress lately effected in this part of science. The two most remarkable facts attesting this progress are, undoubtedly, the extraordinary additions made to our knowledge of existing species, nearly quadrupling their number within half a century; and the discovery of that vast and heretofore hidden world of extinct animal life, which has been entombed, for ages beyond all human count or speculation, in the rocks that cover our globe. The ardour of the traveller and naturalist, aided by the microscope, has rapidly multiplied to our view the species of present animal life. The equal ardour of the geologist, working amidst the strata, which chance or labour discloses to him, has shown what we may well call a series of successive worlds of animal and vegetable life; since, though the general types be the same as those in present existence around us, the species differ more or less in each of the successive periods of time, thus wonderfully brought to light.

Of the two great steps in knowledge here denoted, the latter is doubtless the most remarkable, and replete with problems of the deepest interest; including time as one of its foundations, and thereby bearing on the history and destinies of Man himself. But the extraordinary multiplication of the number of recognised living species, though less striking to the imagination, yet furnishes conclusions hardly less important to the philosophy of life. It is difficult indeed to define, even approximately, the amount of this multiplication, which occurs chiefly, though by no means solely, in the lower parts of the animal series. The powerful eye of the microscope has shown, in earth, air, and water alike, new forms of life, invisible to all unaided sense, but endless in aspect and variety. Every bucket of water taken up from mid-ocean teems with vitality. The dredgings of Forbes and others in shallower seas show different zones of depth, tenanted by different species of animal life. Even the bed of the Atlantic, 10,000 or 12,000 feet below the surface, was found, in soundings for the electric cable, to be covered with the remains of Foraminifera which, for aught we can tell, may have lived at this depth. We all know (and in hot countries cogently feel) how thickly the air is peopled; not merely with the birds which crowd and ornament our museums, but yet more with incalculable swarms of insect life, even more audible than visible to sense. The tropical forest is noisy day and night with the life it contains. The sea is luminous with animal phosphorescence. Nearly two hundred species of glow-worms, and forty or fifty of fire-flies, are catalogued as luminiferous animals of the land. The researches of Ehrenberg, eminently successful among the fossil and living Infusoria, have since been directed to the atmosphere; in which, by appropriate methods, his microscope has detected numerous other minute species heretofore unseen and unknown; yet not indifferent, we may well believe, to those

higher animals, even the highest, which breathe air on the surface of the globe.

Another result of recent enquiry has been our increased knowledge of the Entozoa, and of Parasitic life generally, both animal and vegetable in kind. No natural phenomena are more curious than these. A few examples, seemingly rather deviations from nature than a part of it, formerly comprised all we knew on the subject. Now we may fitly term it a branch of natural history in itself, so numerous are the instances, so definite the relations it involves. When we find even the earth-worm haunted by a parasite (the *Gregarina*) living within and upon it; and numerous mollusks and insects, with peculiar entozoa pertaining to each, we gain some idea of the extent and singularity of these relations. It is not an anomaly we look upon, but a part of creative intent; — an expression of that great design which makes organised life in one form everywhere subserve to the maintenance of another. Exception may perhaps be taken for those species of parasites which are found in diseased animal textures, and in such alone; as we recognise them in morbid states of which man himself is the subject. These curious cases have been considered to sanction the hypothesis of equivocal generation, of which we shall speak hereafter — the disease itself being regarded as antecedent, and the parasitic life as growing out of it. It would be difficult to bring positive proof on this point. It is one reserved for future research; as are those strange analogous phenomena which seem to show that the same ova or parasitic germs, transferred to different organic textures, are capable of evolving different forms of animal life. Minute though these objects be, and inaccessible to all unaided sense, there is no part of natural history which strikes deeper roots into the secrets of the living creation.

Rising higher in the scale of existence, we find in all the

classes into which zoologists have distributed the animal kingdom, the same astonishing augmentation of numbers; less indeed as we reach the higher classes, but even among the Mammalia trebling the number within the time we have named. The birds and fishes made known to us have been still more multiplied; while of insect genera and species, the ratio of increase is such, that calculation can hardly follow it. A commission sent to Brazil for beetles alone, is sure to bring back from that country, so profusely swarming with animal life of all kinds, many species before unknown to the European naturalist. The cases of our Museums are replete to overflowing with these new insect forms from every region of the globe; certainly far exceeding 100,000 in their total number. The British insects alone have been catalogued up to 12,000: the Coleoptera in the collections of Duport and Baron De Jean, at Paris, amount to more than 20,000 species. Of the Butterfly at least 3,000 species have been enumerated; while the catalogue of the Moths almost transcends any numerical estimate.

This augmentation, however, must be qualified by the certain fact, that numerous individuals have been named as species which are not really such. The species has been recorded, where it is only the specimen or variety we have in our hands. How far reduction may be carried on this score, it is not easy to say. Undoubtedly it must be largely admitted hereafter in correction of our actual catalogues.

But we take an imperfect view of life, as it exists on the earth, if attending only to the number of species, vast though this be. The numerical *individualities* of different species — their *richesse effrayante*, to borrow a phrase of Cuvier—is yet more impressive to the reason and imagination. A single swarm of insects, or a shoal of herrings, would in simple numbers represent a populous empire. Without wishing to malign a popular English institution, we might quote the

white-bait dinners of a Greenwich season, as affording some practical idea of the numerical demand which the human kitchen makes upon one rare species. And what is this to the amount of life which the whale imbibes and annihilates at a single draught? What estimate of numbers can we put upon the flies of Egypt, or those continuous clouds of locusts, which for days together darken the sky, and devastate the fairest regions of the earth? Instances of this kind might be given without end; each recording the same marvellous profusion of individual life, made more wonderful by the rapid succession of generations as we descend in the scale of being. Take the single instance of the Aphis. By the most certain calculation of the rate of production in this minute creature (weighing scarcely the $\frac{1}{1000}$ of a grain), it is found that the successive generations from a single Aphis in one warm summer, might amount to a *quintillion* of living beings; — a number so much above all human comprehension, that it offers but a vague row of cyphers to the eye. Or take Ehrenberg's estimate of the 140 billions of infusorial animalcules contained in two cubic feet of the Tripoli slate of Billin, of which rock their siliceous cases form the substance; a wonderful aggregation of *individual lives*, however we may value the grade of being to which they belong.

This marvellous multiplicity, both of individuals and species, is expressed even by the manner in which the *destruction of life* takes place on the earth; and by the vast proportion of the germs and ova of forthcoming life, which never reach maturity. Throughout a great part of the animal creation, there is a strict inter-dependence for that aliment which one species affords to another; and a constant pressure or struggle, greater or less in degree, to satisfy this necessity. It is the same where vegetable aliment alone is concerned; the effect in each case being a continual annihilation of life; — sometimes of species as well as individuals; — and most

abundantly of those germs of existence which in the lower parts of creation are evolved in such countless profusion. The total condition of organic life, from its lowest to its highest grades, is modified or controlled by these several causes, unceasingly in action over every part of the globe.

Our wonder at these things may well be mingled with some degree of awe. For it is impossible to regard them without seeing the great and mysterious problems they put before us. What is, to our reason, this vast design, of which such myriads of separate and successive living generations are the interpreters to our senses? This question, and others collateral to it, are forced upon us almost as a necessity of thought. We see no way open to their solution. That there is a design; that it is not accident, or a blind necessity, which evokes and maintains this world of life around us, need hardly be dwelt upon as matter of argument. The marks of law and mutual relation; of purposes fulfilled by organisation and instincts; are so indelibly impressed on the whole, that no seeming exceptions or anomalies can weigh for a moment against them; or leave a doubt as to the unity of plan, and its derivation from a higher source than physical science can reach. There is no neutrality in this question. To doubt the fact is to cease to reason at all.

But in recognising this supreme creative power, of which to our reason Man is the highest exponent, we are far below any comprehension of the great scheme in which we occupy this place. The question we have stated still presses upon us, as to the design of this profuse variety of life on the globe, so far beyond all reckoning of number or thought? It is easy to gather vague replies from those who look but on the surface, and indulge the belief that all these things were made for man, and his supremacy only. Such cannot be the belief of those who have read the book of nature fully

and fairly. This great volume, while ever multiplying the proofs of power and design, inculcates a more humble interpretation of them; instructing us that we can approach the question through negatives only, which leave us far short of the solution sought for.

The most important of these negatives, undoubtedly, is that just alluded to, forbidding the notion that all other life on the earth was created for the uses of man. We should scarcely stop to argue this matter, were it not that one or two particular points of proof have an interest beyond the simple terms of the question. The first of these is the certain evidence in the long series of fossil remains, of successive periods of animal life so far anterior to man, that no calculation of ours can measure or approach them. Their various forms (from the minute Infusoria, the shells of which compose the mass of many of our existing rocks, to the huge and strange aspects of the Oolitic and Weald reptiles, and the endless other varieties which now fill our catalogues) were doubtless adapted to the several successive conditions of land, sea, and air in which they had their existence. But no reason or plausible hypothesis can bring into connection with the human race these tenants of an elder world. We may recognise the fact that the forests of those remote ages gave origin to the beds of coal, which for the last two hundred years have ministered so largely to the uses and powers of man. But we cannot equally apply this argument to the *animal creations* which have preceded us. No more direct relations than those of type and structure connect, as far as we can see, this ancient animal life with that of our own day. No purposes or final causes can be assumed as a necessary link between them. Any notion of *tentative acts* of creation must at once be put aside. To say nothing of the change it makes in our conception of the Creator of all, such notion is wholly contradicted by the actual gradation and

intermixture of life in these successive epochs. That creatures of higher organisation are found in the later than in the earlier periods, — and highest of all, in the existing world, — is well assured as a fact. But this fact is limited to a general denotation of progress. The steps in the series are blended and broken; and Man walks the earth surrounded by beings as low in the order of life as any which the first fossiliferous rocks disclose to his view.

This argument is drawn from the ancient part of creation. We take another from that part of it nearest to man; — if not in date of time, of which we are ignorant, yet certainly in all that relates to physical organisation and intelligence. We allude here to the Anthropoid Apes; and very especially to the Gorilla and Chimpanzee, which have lately engaged the especial attention of our most eminent naturalists. These creatures, thus far approaching Man in physical features and certain intellectual functions, have no relation to him besides, save as the rare and short-lived tenants of his zoological collections; where they are gazed upon for a few months by the curious, and then pine away and die. They are few in number; inhabit very limited spaces; are seldom seen by man in their native haunts; and minister to none of his uses, directly or indirectly. They might altogether disappear from the earth without leaving behind mark or memento of the change.

An instance, thus special and significant, renders needless the many and obvious proofs which might be drawn from other parts of creation. In fact, we only touch upon this subject as a part of that great problem of life upon the earth, which is now deeply engrossing the philosopher as well as the practical naturalist, under the shape of questions far better defined than in the earlier ages of human speculation. That the great design of the Creator on our globe extends beyond, and comprises more than, the mere present exist-

ence of Man upon it, may be fully urged without degrading the latter, or altering his place in the scale of created beings. Highest in organisation — supreme in intellect and the moral sense — *single* in his capacity for language — ministered to in every way needful to his bodily wants, and to his higher feelings and sense of beauty, by nature animate and inanimate around him — capable of raising himself, by his faculties of reason and imagination, far beyond the world he inhabits — this is a being whose nobility cannot be degraded, or his high destiny annulled, by admitting that the earth is not a dwelling-place for him alone in the purposes of creation.

Nor is our conception of the Creator of all narrowed or impaired by this recognition. He has given existence to man. He has given life to countless other beings, inferior to man, but independent of him. To confess our utter inability to say why these things are so, is but to add another to the questions unapproachable by reason, and which it is our wisdom to recognise as such. We are sure that there is design, wise in result and certain in its fulfillment. The doctrine of *Final Causes* has incurred some discredit, not from any inherent fault as a principle of reasoning — for this is unimpeachable — but from the rash and premature endeavours to carry it beyond the bounds of just induction.

We come now to another class of questions respecting animal life, more special in character; questions which have been, and yet are, the subjects of warm controversy, and strikingly illustrate the spirit of modern enquiry. We allude to those regarding the true nature and definition of species; — their capacity for change or transmutation; — the existence of types in the different grades of animal life; — the relations of date or order of succession of these several types, genera, and species; — their connection with *different* geological periods; — and, lastly, the manner of generation

or reproduction, so essential a part, as we have seen, of the definition of life itself. All these questions are closely allied; yet each is so large in its objects and details, that volumes have failed to exhaust the argument. We shall take them up chiefly on points which may best show the character of the controversies to which they have given rise. That some of these controversies have been carried on with bitterness can scarcely create surprise. The new doctrines put forward have in many ways contradicted harshly the opinions held heretofore; and offence to the sober-minded adherents of these opinions has been increased by the bold and dogmatic tone which some of their opponents have assumed, and the extreme conclusions to which they have pushed their material hypothesis. Such discussions, moreover, deeply involve the relations of Man to the rest of the living creation; verge on various points of religious belief; and in these respects well explain the earnestness given to their pursuit. In what we have to say of them, we shall seek to put each topic in its simplest form, and to deal with all impartially; as questions which science has raised, and for the solution of which, if attainable at all, we must look to science alone.

First, then, among these questions comes that of the nature and permanence of Species, as distinctive of the different forms of animal life from the highest to the lowest. Our scientific readers need not be told how warmly this question has lately been agitated by naturalists. The controversy, which had its birth in France, and there provoked personal animosity as well as scientific dispute, was translated to England in a mitigated form; but has here also stirred up the depths of an argument, stretching beyond the limits of former enquiry, and liable in some part to the imputations of which we have just spoken. The laws which have governed the creation and succession of living beings come

at once into the question; while the doctrine of transmutation of species regards man himself as a possible developement from forms lower in the scale of life.

The whole argument, in fact, concentrates itself on this point. Are Species — best denoted as such by sexual character and the power of propagating their like — to be considered fixed and immutable as they came from the hands of the Creator, or subject to such variations only as tend always to return to the original type? Or is there an inherent habahty to or faculty of change, either from accident or the operation of common laws, which can, and does, in the course of time, create new species out of antecedent ones; an extension in effect, and higher result, of that very principle of change by which varieties and races are brought into existence? The great name of Cuvier appears in the foreground on behalf of the former opinion: Geoffroy St. Hilaire made himself the chief of the opposite party. In England, the transmutation doctrine first gained currency through that well-known work the 'Vestiges of Creation;' and has since been espoused by other writers of great and merited reputation. Many of our most eminent naturalists, our geologists especially, have entered with earnestness into a controversy, rendered inevitable from the progress of their science and the new phenomena ever coming before them. Looking generally on the conflict as it now stands in this country, we still find a predominance of opinion for the fixity and permanence of species under the definition we have given. But at the same time we notice a certain cautious reserve in announcing any absolute or final opinion on the subject; an effect doubtless of the ambiguities which still surround it, and the difficulty on each side of reaching any other than presumptive proof. While approaching the question ourselves in this spirit, we shall seek to frame our argument as a vindication of the older belief; feeling that

this cause is one not to be lightly given up to the demands of a new doctrine, still unproved in some of its most essential parts.

The *onus probandi*, indeed, unquestionably rests here with those who believe that species can undergo such transmutation, as permanently to change the conditions upon which this distinction has naturally, or even necessarily, been founded. It is their business to show some unequivocal instances of perfect transmutation; or, in default of this, some such approach to it, by gradations manifestly progressive, as to warrant the presumption that time only is wanting to complete the change. Less than this cannot be received in evidence of fact, however plausible an hypothesis of possibilities may be made to appear. The limit-line drawn around each species, by its power of self-reproduction, may not be broken through without more complete proof than any yet proffered to us. No unequivocal instance has hitherto been obtained from any part of the animal kingdom to satisfy fully these conditions. The question therefore remains one of possibility and presumption only. Possibility cannot be denied; but the advocate for the permanence of species, resting upon much that is assured to his knowledge, has a right to ask that the opposite doctrine should be fairly fortified by fact before its admission even as one of the outworks of science.

The arguments for the hypothesis of transmutation are, mainly, the variations which species actually undergo; and which in many cases, especially where man is the artificer of new breeds, become fixed and hereditary;—the fact that in a certain number of instances the intermixture of species is prolific;—the existence of certain archetypes or general forms, upon which the many specific forms are founded;—and the tendency of all research, in the fossil as well as living world, to bring the gradations between these forms into closer con-

tact; filling up, more or less, thereby the void places in the series of genera and species before known.

Other arguments there are, but these lie at the root of the question, and may be taken *instar omnium*. In pursuing the controversy, one party has found it needful to assume, and the other to allow, an unlimited license as to time. We do not go over the geological proofs as to this matter, now become so familiar to all. It is enough to repeat, that prior to man and all the creatures occupying the world with him, there have existed on the earth successive and separate conditions of animal and vegetable life, as faithfully recorded in the rocky cemeteries below us, as if they were the creation and destruction of our own day. Though the order of succession is distinct here, no human estimate can reach the period of time these successions involve; so vast is it, and so broken by intermediate changes to which no measure can apply. In one sense then, that of the existence of life on the earth, time has no numerical limit which we can assign. But the advocate for transmutation of species must take it, subject to a question as to the nature of these intermediate changes or catastrophes. If they be such as to close one epoch of life on the globe before the creation or commencement of another, then the argument, as far as time is concerned, must be limited to that latest epoch in which we are now placed. Many of the *gaps* in the structural scale have been filled up, indeed, from the fossil remains of former periods; but until some series can be shown connecting these periods together without breach of continuity, the hypothesis of developement or transmutation cannot fairly borrow time from these anterior epochs, for the changes it presumes.

Nor does it really lose much by this limitation. The fossil remains of former ages of life afford no evidence as to transmutation of species, which may not as plausibly be drawn from the existing animal creation. We find the same general

types of structure, declaring to our reason the *unity* of the creating cause, but evolved under many and singular diversities of form; — with the special fact superadded that each epoch contains species peculiar to itself. Different species more or less approximate to each other; but in none of these periods have we yet found any such series as to indicate an actual passage from one to another; or anything more than this proximity, itself expressed in all cases by the same special forms and relations of parts.

There is, however, one point of connection between these periods, which bears in some sort on the question before us. We allude to the fact - indisputable in itself, and deeply interesting in all ways - of the successive appearance of higher types of organisation and conditions of existence, in rising from the earliest of these epochs to that in which we have our own being. We shall revert to this topic hereafter, and notice it here only to show that it does not sanction, or even favour, the doctrine of transmutation. There is no regular gradation either as to time or type, such as the theory would require. New and higher forms of life come in with new epochs, and continue to be associated with the lower types that before existed. Recent research has carried back some of these higher forms into geological ages more remote than was once supposed their limit; and this may go yet further. But it would not then, more than it does now, affect the argument we are holding.

The existence of such common types or *plans* of structure, extending throughout the whole domain of life and giving foundation to all special forms and varieties, may seem at first sight to furnish some valid argument for transmutation; and the more so since these types are found in one sense to graduate into one another. The individuals of higher type throughout the several great groups of the animal kingdom, pass through certain stages of those lower in the scale,

even as far down as the simple germ of the Protozoa, before reaching their final and special organisation. Of this very curious fact the human structure itself is an example; a fact not neglected by those (and, strange to say, from paradox or petulance there are such) who love to degrade man in the scale of being. The attempt is a futile one. The Protozoon stops at his destined place in the lowest scale of being. Man reaches by definite steps the high organisation which is designed for him. Each of these, and every species intermediate in the animal world, attains, and is arrested at, the point marked out for it in the long line of created life.

The whole subject of types is one of the deepest interest. The doctrines of St. Hilaire led him to refer all animal life to a single primitive type only. Cuvier, followed by the far greater number of naturalists, has denoted four as absolutely marked and distinguished in nature. Subordinately again, or included within this theory of types, comes the more recent doctrine of Homologues; teaching us the relations of *equivalent parts* of structure throughout the animal world. A fine conception of Goethe - half poetry, half philosophy became, under what we will not call the sober enquiry of Oken (for the genius of Oken has no mark of sobriety upon it), but became by his research and that of other naturalists, an integral part of natural science. Had we space for it, we should gladly put before our readers some account of the valuable contributions of Professor Owen to this curious branch of knowledge; -- the researches by which he has confirmed the view of the Skull as an extension of the vertebral column; — and his remarkable work on Limbs, in which portions of structure in different animals, seemingly the most unlike in aspect and use, are all resolved into common relations of typical structure. These things must be regarded not as mere naked facts, but as the interpreters to our reason of an Almighty design, in action from the earliest ages

recorded in the rocks below us; of which Man himself, highest and foremost in the series of types, appears to our present view as the consummation. But we have no right, on this latter point, to dogmatise as to that futurity of time and change which goes so far beyond all human knowledge or comprehension.

From the system of types, however, the advocate for transmutation of species can draw no fresh argument for his doctrine. It is still a series, more or less complete in its parts, of which each member or species, in past as well as present periods, has its defined and specific characters; and continues to have them as long as its existence comes within our view. The type, whether general or particular, represents to us certain common outlines (*ideas* we are tempted to call them) in the scheme of creation, to which these separate members belong as individual parts. Were there anything like actual transmutation amongst them, we might expect to have our catalogues crowded with instances of this in every stage and aspect of its progress, or even to have evidence of it under our own eyes.

This brings us to what is a main argument in the matter; viz., the variations which actually occur in living species, and which strongly tend to become hereditary, if the causes of variation be continued. Examples to this effect are so numerous and familiar that it is needless to cite them in detail. They occur most strikingly among animals domesticated by man, or artificially bred for his uses or pleasures. But they are produced also by variations of climate, food, and other physical conditions tending to perpetuate certain forms at the expense of others; — sometimes also by those more mysterious influences of generation, of which we can say little more than that they exist; and, existing, must be the source of numerous facts and anomalies, to which neither reason nor research furnishes any other clue.

In Man himself these varieties take their highest, and perhaps most heterogeneous character. They are testified especially in the difference of races; a distinction so strongly marked in particular cases, as to have led some naturalists — erroneously, as we believe — to refer it to an actual diversity of species. That strangely familiar friend of man, the Dog, produces varieties scarcely less numerous and remarkable. An eminent French naturalist has stated that if we were to reckon as species the different breeds of this animal, we must carry the account above fifty. The extent to which such deviations may proceed and become hereditary in a race, is one of the most curious enquiries in natural history; as well in reference to the authentication of true species, as in connection with the subject of Animal Instincts, to which it is closely related. We believe that there is a natural limit to change in each particular case; and think it probable that the deviation, though differing under different conditions of animal life, has already reached its maximum in the animals bred and domesticated by man.

Even here, then, the advocate for transmutation fails to make good his case; since it may almost be affirmed that the particular capacity for variations in each species forms in itself a *specific* character. These varieties or deviations are not changes *of* species, but changes *within* them; and, with few and ambiguous exceptions, are confined to certain limits which the law of reproduction of species strictly defines. This law, in truth, comprises all the cardinal points of the question. It is a natural definition put before us, and so strongly marked, that the argument as to design might well be made to rest on this alone. If an instance could be brought of the intermixture of two species in generation producing a fertile offspring, capable of breeding with *similar hybrids*, or otherwise perpetuating the physical changes induced, the law would doubtless be impugned in its

generality; and the possibility might be urged of numerous such instances, if time and chances are taken into account. But we doubt much whether, in the animal kingdom at least, an unequivocal case of this kind really exists. It may be admitted that several hybrid species (the equine, canine, ovine, and, possibly, but less certainly, some other animals brought immediately under human culture) are to a certain extent prolific.* But the true hybrid does not propagate with the hybrid; and its power of propagation, even with the perfect species, is very limited in degree, and soon comes to an end. On the other hand, we believe there to be no recognised instance of absolute infertility in two varieties of the same stock, however wide their deviation from each other. This argument, then, for transmutation halts on the very threshold; and, duly examined, may even be appropriated for the opposite conclusion.

The sexual relations cannot be omitted as a point in this question. Weighing fairly all the circumstances — and, amongst others, the *period of gestation* (different even in the cognate species of the dog and wolf, though alike in the dog and jackal) it appears almost certain that no real or permanent change of species can take place without a concurrent mutual adaptation of the two sexes in its progress; — a contingency so improbable, seeing all that is required, that we cannot but regard this as one of the most cogent objections to the doctrine before us, and meriting more attention than it has usually received.

A word or two more must be said in regard to the varieties in species themselves. Strictly speaking, these are not so much structural differences, as variations in size, configuration,

* We are bound to notice here the experiments of M. Roux of Angoulême, who succeeded, by the inter-breeding of hares and rabbits, in producing a new hybrid race, fertile, as he alleges, without reversion to the original stock. Further research is required to attest the duration of this fertility.

integuments, colour, and other external characters, subject in each case to limits which they cannot transcend. The despotic folly of a Prussian monarch might breed, as well as steal, gigantic soldiers for his guards; but could not change in a single particular the anatomical characters of the men thus forced into his ranks. We have before referred to the Dog. With the exception of a slight change in the bones of the hind foot in some breeds (the maximum of variation, as far as we yet know) the bony structure and internal organs are the same under all its numerous varieties. The teeth, now so important a diagnostic mark, are alike in all. Its animal instincts, though modified, or often suppressed, by human culture, are essentially the same throughout; and the dog himself well knows his own species, whatever varieties it assumes. It is needless to cite other instances, as they all correspond in their bearing on the question before us.

A point upon which stress has been laid by the disciples of Lamarck is the close approximation of the Anthropoid Apes to man; warranting, according to them, the notion that the lower may here have passed into the higher grade of being. Admitting the likeness to its fullest extent (the *Simia quam similis!* of the old Latin poet), it is still but the mark of closest proximity in the scale. The evidence, either anatomical or of other kind, as we have already mentioned in speaking of these creatures, goes not a step further. And against the transmutation hypothesis here, we have the fact stated by Owen, that certain of the osteological differences between these animals and man are so characterised as to be insusceptible, from any known external causes, of the changes required to accomplish such transmutation.

The arguments we have now been using for the permanence of species will be familiar to many of our readers. But there are others to whom the question has come only in a crude and general way; and to these it is well, seeing how deeply

this enquiry strikes its roots into the mysteries of creation, that it should be presented in such form, as to make clear the distinction between what is speculation only, and what a sound induction from the facts which science has disclosed. We may fairly use the word *vague* here, as descriptive of the manner in which the doctrine of transmutation is propounded to us. There has been no distinct understanding as to the foundation, or first steps, of the scheme supposed. With some it is a notion of gross materialism altogether. Genera and species of living beings come into existence through undefined combinations of matter, and are mutable without limit from material causes acting upon them; - or, as some prefer to phrase it, from a *nisus* of the animal itself to obtain new scope and powers of existence. Others, more modest in their assumptions, have supposed a few original created forms, capable of gradual developement into new species, unlimited in variety, if unlimited time be given to work the transformation. We cannot reasonably require any actual date for the time thus demanded. But we may fairly complain of the vague asseveration on which the whole scheme is built. We have a right to ask for some denotation, however general, of these primitive beings, the parent stems of the genera and species we now see around us. The doctrine of types, as already explained, furnishes no reply here; nor to the questions we have a further right to ask, whether any of the primitive forms yet remain in existence as such? Or whether the principle of change is now exhausted in power, and the existing genera and species represent a scheme of transmutation worked out to its end? Other questions equally press for answer, showing how unstable the hypothesis is in its first principles; and how little fitted, upon *present proof*, to meet the demands of a sound inductive philosophy.

In arguments of this nature, it is of great value to obtain

such instances as are not only indisputable in themselves, but extend their conclusions to other kindred cases. The Electrical Fishes appear to us to furnish a striking example of this kind. From what processes of transmutation can be derived the several forms of bodily apparatus in these animals, capable of generating this singular power, and putting it into action by their will? The argument is analogous as relates to the Poisonous animals, whether reptile or insect in kind. The differences of the poisons themselves, and of the parts instrumental to them, are such as to annul all idea of primitive community of species, even in the case of the venomous serpents, where it would be most natural to expect it. The same reasoning might be applied to the Luminiferous animals; and to many other cases, where some special property or provision pervades many species, yet leaves distinct and lasting the individuality of each.

We might find a further argument in the different, yet definite figure and size of the blood-corpuscles in different animals; a very curious subject, but not yet enough explored to furnish any certain inferences. The reasons we have stated, however, are presumably sufficient to justify the belief, not indeed in all that have been denominated *Species* (for doubtless many mere varieties and duplicates are catalogued as such), but in the fixity and permanence of the majority so recorded. No sound reasoner will raise an objection from the multitude thus supposed distinct in their origin. Whether we look to the great or small in creation; whether to the stars of heaven, or to the infusorial animalcules of our own globe;—equally must we regard *number* in the hands of the Creator as a thing wholly apart from our own feeble and limited conception of it. The miracle to us is the *act of creation* itself. This recognised, (and can it be denied?) the exertion of the power is subject to no artificial limit of ours. A hundred and a hundred

thousand are the same to all actual or possible comprehension of the matter.

We have already spoken of the manifest design in the vast and various profusion of life spread over the earth at successive epochs; and we may now advert to another case, where designed progression is obvious to our reason, though in a different sense from that of the progressive transmutation of species. This is the fact — already adverted to, and well authenticated — of the successive introduction of higher forms and attributes of life into the series, as time has moved onwards through the ages anterior to our own being on the earth. From the period when the Cephalopoda were supreme in the animal kingdom, to that when Man became its head, we have a series of types, each rising in organisation, of which Fishes, Reptiles, Birds, and Mammals represent the most remarkable forms. The only controversy as to this point has arisen from certain seeming irregularities in the order of succession; these higher grades of life coming in without any apparent conformity to our measures of time or relative change. But the main fact is in no way impeached by this irregularity, and *intention* is on the very face of it. Making every allowance for our inability in many cases to say which of two proximate organisations is highest or most perfect, we cannot doubt as to the relative character of the fossils of the Silurian and Devonian ages, and that of the Oolitic remains, where the Mammalia first come into view; — nor, again, can we hesitate as to the relation of Oolitic life to that of our own day.

We may quit this subject with the general remark, that if transformation of species be ever proved, it will probably be so in the lowest forms of animal life, where the organisation is of the simplest kind, and where the functions seem limited to mere maintenance and reproduction; — the latter, moreover, effected in some of them by means very different from the

analogies of higher animal life, and more akin to the characters of the vegetable world. Even here no actual transmutation has yet been made known; and the argument we have been stating remains therefore still untouched. But we are bound to add, that much and able research is now in progress, bearing on this question of the true definition and limitation of species; and followed chiefly through the phenomena of breeding and hybrids, as the best and most legitimate mode of approach to its solution.

All these topics have close mutual kindred; and we have taken advantage of this, to bring into the foregoing argument many collateral topics illustrating the vocation and spirit of modern science. We now come to another question, linked into the same chain, viz., that of spontaneous or equivocal generation; the enquiry whether new species are still brought into existence, or have been so, within what may be called the *human period* of life on earth? We know that certain species have utterly passed away within this period; and that others are in assured progress towards extinction. Man himself has been largely concerned as the agent in these changes, whether of diminution or annihilation; but physical conditions have doubtless also had effect. Is there anything in the nature of an equivalent to them, by new acts of creation, or by the spontaneous production of fresh forms of life?

Here again we are without a single fact in absolute proof. The extinction of certain species (and these, as far as we know, exclusively of the higher animal orders,) does in no way imply the creation of others; and the only affirmative presumptions that can be offered are drawn from those minute and obscure forms of life, where the sexual distinctions are little marked, and the functions of reproduction of unwonted kind. Accordingly, we find that those who hold this belief dwell much upon the Entozoa; and yet more on the appearance

of animalcule life in various artificial compounds of organic matter, under forms peculiar to each. The latter fact is as incontestable as it is curious. But the conclusion from it must ever be a doubtful one; seeing what we know of the wonderful retentiveness of reproductive power in the ova or germs of such animalcules. We may readily conceive, and we actually know, the continual presence of these invisible elements of life in the earth, air, and water around us; ready to start into form the moment the physical conditions are present which can give them their proper *habitat* and nutriment. Many analogies in the vegetable world familiar to naturalists favour this view; and none, as far as we know, contradict it. The argument for spontaneous generation from the Entozoa is refuted by the fact that, with the exception of a few species which propagate by budding, they have all male and female organs. The Polygastric Infusoria have been brought in to support the doctrine. But in all the varieties of these animalcules there are fixed and invariable forms; and these, it may be added, closely assimilating them to the fossil infusoria, which existed ages ago.

Thus far, then, the opinion rests on very slender authority. We may add one argument, not usually quoted, yet as valid as any of the foregoing; viz., those new forms of epidemic pestilence, which from time to time have appeared in the world, devastating whole continents in their progress, and depending, as we are disposed to believe, on organic and living matters diffusing themselves as the virus of disease. In no other way, as far as we can see, are these wandering pestilences to be accounted for, than as derived from a *materies morbi*, capable of *reproducing itself*, and therefore coming strictly under the character of life. But here again, while admitting this view, we cannot affirm that the germs may not have existed for ages before, awaiting develope-

ment; and the argument therefore is as loose in proof as all others which bear upon this question.

We pass here by a short step to another topic, one of the most interesting, but most obscure, in natural history, that of the *reproduction of life*. Modern science, active as we have seen in its interrogation of all nature, has eagerly explored this subject, and obtained many new facts and conclusions; but none which give a key to the ultimate mystery of life propagating similar life. The steps made are all intermediate; in no respect are they final or complete. We may refer, for example, to the recent discovery (due to the microscope) of the *cell structure*, as the first distinct development of individual life, and the rudiment of future growth both in the animal and vegetable world. In the zeal with which physiologists have adopted and pursued this discovery, there has been somewhat too high an estimate of its real value. The fact, indeed, is curious and unexpected; but it carries us onwards by a single step only. Cells themselves, with whatever nuclei they may contain, must be derived from some more primitive germ or aggregation of matter; and when we read of *cell force* and *cell growth*, we have reason to ask what these terms really convey to us. It is even easier to conceive of growth from minute vascular structure, than from cellular aggregation: but both conceptions leave untouched the great problem of generation; the assumption of *infinitely different* but *perfectly definite* forms, from rudiments thus simple and seemingly similar. We feel that there is something beyond which no hypothesis, however bold, can cope with; that we are yet far from reaching to that mysterious principle or power, by which the life of individuals and species is elaborated and maintained, generation after generation, under every grade of likeness or diversity, each equally inexplicable!

Modern research into these phenomena has not been

limited to the discovery of formation through cells. Other strange facts and seeming anomalies, in some part indicated by earlier naturalists, have been subjected to more exact enquiry; and, had we room for it, we might state many most curious results, particularly as regards those phenomena which the researches of Steenstrup and others have disclosed to us. The Greek, 'that musical and prolific language of ancient philosophy,' has been drawn upon so largely for scientific purposes in our own time, that we cannot quarrel with such terms as Metagenesis, Partheńogenesis and Agamogenesis, though somewhat ostentatious as applied to the most minute objects in creation. They serve to betoken what are indeed very strange and complex modes of reproduction; in which the sexual influence (though not lost, and in some part and form always necessary) is in certain cases so wonderfully concentrated *concreted* we may express it in the organisation, that a dozen generations may be evolved in succession without any renewal of the male influence in reproduction. This fact has been amply established by experiments reaching as far back as the days of Reaumur and Bonnet, and is well exemplified in the instance of the Aphides; the diversities of which viviparous or oviparous, winged or wingless, alternating or without obvious rule of succession offer a multitude of problems to sober, as well as to speculative thought. This budding forth of a germ principle through successive generations from a first single fertilised germ, while closely connected with the principle of animal metamorphosis, is the fact which, more than any other, forms the link (very difficult indeed to dissever) between animal and vegetable life. The Entozoa, Polypi, Medusæ, &c., all enter into and illustrate this great natural relation. The phenomena of fissiparous generation variously and strikingly attest it:—those curious cases where entire and repeated division of the animal does, under certain limitations, repro-

duce the perfect form in each of the divided parts. In some of the Infusoria, the problem is further perplexed by a double manner of generation through ova, and by self-division of the animalcules themselves.

All these things, and others equally wonderful — such as the modes of parasitic or complemental generation described by Mr. Darwin in his Monograph on Barnacles — may well astonish those who come unprepared to the subject. In reality, however, there is nothing more unintelligible here than in the familiar facts of ordinary generation, nor more wonderful than what we before knew as to the economy of other animals higher in the scale of creation. The modes of reproduction of the Bee (especially as last developed by the researches of Dzierzon and Von Siebold) may be taken as an epitome of all that is most marvellous in this great function of life. The true mystery, as we have already said, lies deeper; and is equally associated with every variety and aspect of these phenomena. It is one of the many cases in science and philosophy where familiarity gives a semblance of knowledge; satisfying the shallow enquirer, but otherwise estimated by the more cautious seeker after truth. The several questions we have been discussing, and others not less difficult of solution, are all subordinate to the single problem of the *transmission of life and likeness* from one living being to another. All theories and systems are alike arrested at this point. The problem, in truth, is one insoluble by the present capacities of man.

Another topic of eminent importance to all our views of life, and the economy of living beings, is that of Animal Instincts. Much has been observed, thought, and written on this subject; but less connectedly, we think, than its interest requires. Facts have been multiplied and better defined; and the special structures serving to the fulfillment of instincts more carefully, yet for the most part vainly

explored. For the great problem here remains as entirely unresolved as in the earliest days of ancient philosophy. What is the source or proximate cause of those actions — definite, peculiar, and permanent in each species — which we call *instinctive*, as distinguished from the acts of reason and intelligence? The main points of doubt, speculation, and controversy are all concentrated within this question. It involves one which in some sort is precursory to all, viz., the reality and nature of the distinction between reason and instinct; faculties so closely bordering on each other, and often so blended in the same acts, that it becomes difficult to distinguish or dissever them. To obtain a just definition, we must look at the more simple and extreme cases of each. 'The absolute hereditary nature of Instincts; — their instant or speedy perfection prior to all experience or memory; — their provision for the future without prescience of it; — the precenseness of their objects, extent, and limitation; — and the distinctness and permanence of their character for each species,' are the more general facts upon which we define true instincts, and contradistinguish them from the acts of mind and reason. These two great faculties may be said to exist in inverse ratio to each other throughout the whole scale of animal life. Where intelligence is highest in power and effect, instinct is lowest and least in amount. It augments progressively as we descend in the series; and at some point, hardly to be defined, seemingly embraces and gives origin to all the acts of animal existence.

The only probable advancement, as far as we can see, in the theory of Instincts, will be through such researches as may determine their more exact relation to reason in the same individuals or species. The very blending of these faculties in the higher order of animals, while it perplexes in some points, does in others offer the chance, if not the certainty, of illustration to both. Without undermining the

distinction between them by metaphysical subtleties, we may well admit that the questions they suggest are in great measure the same in kind, and of like difficulty in solution. The method of research we suggest through these common relations, though often touched upon in part, has never been systematically pursued. It would require varied experiments, as well as minute observation. It must of necessity be an assiduous labour, and divided among many; but also a labour of high interest, and aided by numberless facts already ascertained, but not yet collated or reduced to order. A systematic work on Instincts, derived from every province of animal life, and carefully brought into relation with those various degrees of reason which animals possess, would (even if but partially completed) be of high value to physiological science in its every part.

Associated, though less closely, with the foregoing topics, comes another enquiry which has earnestly engaged the naturalists of our day; viz., the manner of distribution of the types, genera, and species of animal life over the surface of the globe. The diversities of such distribution have long been noticed; but to botanists, and especially to Decandolle, we owe the first clear conception of geographical provinces, within which are located certain predominant typical forms, diffusing themselves as from a centre;- arrested in some cases by the intervention of sea or land; - in other cases mingling on the border with the types and characters of other provinces. In animal life also we find this local distribution, with conterminous mingling and affinity of genera and species, strongly marked; and though the boundaries of such provinces are still not fully defined, we are sufficiently assured of the fact to reason upon it as a part of the living economy of the world. And a most curious fact it is; depending, as it must do, either on the original conditions of animal creation, or on the great revolutions of the earth's

surface, recorded by geology; — those mighty interchanges of land and ocean, by which continents have been raised or submerged, climates changed, and all living nature brought into subjection to this elemental strife.

Australia is generally quoted as the most striking example of such local limitation of forms, both in animal and vegetable life. This strange Continent — scarcely known a century ago, now the flourishing seat of British empire in the Southern hemisphere — stood, when discovered, in a sort of solitary contradiction to the rest of the known world. Of 4,100 species, forming its earliest recorded Flora, only 106 were found elsewhere. The Eucalyptus and leafless Acacias, in their numerous species, inflicted a sombre hue on its scenery, while the marsupial animals, with other strange configurations of animal life, gave an eccentric and paradoxical character to the Fauna of this region. The Galapagos Isles, so well described by Darwin, furnish another example even more striking from its limitation. These isles (volcanic in origin), though but 600 miles from the South American coast, yet form a distinct province both in their Flora and Fauna; with scarcely a single organic production which is not aboriginal in species, and unknown elsewhere. South America itself is the peculiar domicile of the very singular order of Edentata, or toothless animals, which are here found both living and fossil; while north of Mexico they are unknown except in the fossil state. The Sloth, that strange and grotesque member of this order, and the Armadillos, are found in America only. New Guinea, with some island groups to the east, forms a particular zoological province; singular from being destitute, with one exception, of all warm-blooded quadrupeds. The Elephant, Rhinoceros, Giraffe, Hippopotamus, &c., are limited now to certain portions of the old world, though their fossil remains are much more widely diffused. The marine animals, much more vaguely of course,

give evidence to the same fact of local limitation; and even lake and river fishes demonstrate it, comparatively narrow though the spaces are which they occupy. We may seem to see reason why the Salmon, found in all countries bordering round the Arctic Circle, should nowhere exist in the Southern hemisphere. But how are we to explain the different families of fish, found by Agassiz in each of the great fresh-water lakes of North America, connected as they are by a common river? Or how the fishes peculiar to the Ohio and many other rivers? Or the species limited in existence to some of our own rivers and lakes?

Such instances, which might be endlessly multiplied, show how curious are the problems belonging to this part of natural history; and how perplexed in every part by the doubt of what may belong to a primitive geographical distribution of created beings; — what to the revolutions of the surface of the globe, paroxysmal or gradual, which have since intervened. The argument for the former, supported as it is by the complete analogy of vegetable life, is too strong not to compel belief; though leaving it doubtful to what extent the limitations of localities and species originally existed. Further research may do something towards clearing away these doubts, but can never wholly remove them. The unquestionable changes in climate and other physical conditions essential to life, from geological revolutions on the earth's surface; and the mighty influence of Man when he became a tenant of the globe, in multiplying, destroying, or transplanting whatever of the living creation existed around him, have removed many of the marks or outlines which might have denoted this primitive distribution. Fossil geology to a certain extent comes in aid of the research; though in solving some questions it evokes others not less difficult. In the vast periods of time through which it carries us, we see the same revolutions of surface, elevations, depressions, and

changes of land and sea; but the farther we recede from our own time into these depths of ages, the more entirely do we lose all analogies of geographical distribution. 'Even in some of our most recent strata,' as Professor Owen remarks, 'fossils occur for which we must seek the representatives in America; and to match the mammalian remains from Oolite, we must bring specimens from the Antipodes.'

In treating of these various questions which have relation to Life as the subject of modern science, we have only partially alluded to the enquiry denoted by the special term of Animal Physiology; the history of those organs and functions through which vitality receives and maintains its individual existence. This subject, in truth, is too vast in outline as well as details, and the discussions it embraces too various and important, to be dealt with in any single Article, even exclusively thus directed. The functions of nutrition and assimilation, of circulation and respiration, – of secretion and excretion, and of the nervous system in its several parts, all these have been the objects of refined experiment and sedulous observation by the physiologists and physicians of our day; and with results which give a new face and form to this branch of science. But while putting aside the subject at large, there is one class of the functions just named which we cannot wholly omit when treating of physical science in its relation to vital phenomena. We mean those wonderful functions which are fulfilled through the instrumentality of the nervous system, and which we cannot err in describing as of far higher interest than any others of the animal economy; seeing that they connect the *conscious being*, whatever its grade in creation, with every part of its own organisation and with the world without. Sensations in all their forms, volitions in all their acts, find transmission solely through this portion of structure;— one so little intelligible to the eye or outward

observation, that not a single anatomist or philosopher of antiquity placed a right interpretation on its nature and uses. Modern science has encountered the subject with the better appliances of experimental enquiry; and though much remains to be done, and much more may be deemed wholly unattainable, yet we can safely affirm that some of its greatest achievements are to be found in the anatomy and physiology of the nervous system.

Into the details of these discoveries we cannot enter. They relate chiefly to that organisation and distribution of nervous matter (including the Brain as its highest development) through which this power is generated and transmitted in fulfillment of the various functions of life. They include yet further the especial relation between the several parts of the nervous system and their different functions; whether such as appertain to animal life appropriately, or those more purely of organic kind. This latter distinction in itself may be deemed a recent discovery, and one prolific in curious and instructive results. So, in truth, are all those discoveries which connect particular parts of the nervous system with the offices they fulfill; from the highest and most complex forms of this structure in man, to the bare manifestation of it in the lowest grades of animal life. Every step in these researches opens out new views to the speculative eye, and offers new problems for experiment and reason to resolve. The successive and successful labours of Bichat, Bell, Magendie, Marshall Hall, and other physiologists, thus directed, have been more recently extended by those of Brown Sequard, to whom we owe many interesting facts in this part of animal physiology.

Among these various topics, there is one question so closely allied to some we have been discussing, that it cannot fitly be put aside. Is there any special physical agent, acting in and through the nervous system, and by such action giving

fulfillment to its numerous offices in the living economy? Or must we look to some mysterious power existing here, apart from matter and the forces acting on matter, as needful to explain the phenomena, and particularly those which connect the nervous system with consciousness and the mental functions? This question, like the analogous one as to a Vital Principle, presses upon us almost as a necessity of thought. As in so many other cases, language has sought to evade the difficulty of solution by phrases more or less convenient for use, but which indicate no new or real knowledge acquired. We employ the terms of *nervous power*, *principle*, *energy* and *element*, *nerve-force*, *innervation*, &c., all preferable, doubtless, to the older phrase of *nervous fluid*; but preferable simply because less definite in their assumption of meaning.

To the question stated above, science has yet rendered no certain answer; but there are several presumptions favouring the view that some physical agent - analogous to, if not the same as, the natural forces of which we have so often spoken - does directly minister to the functions of the nervous system. One of these presumptions is founded on that conception of *quantity*, which is forced upon us in every consideration of nervous power, and is expressed equally by excess or deficiency in amount. We exhaust energy by action; we augment it again by time and rest. Scarcely can we name a function of life which does not include the fact of a power inherent in it, thus varying in degree. Whether we can apply the term *intensity*, as separate from quantity, is more doubtful; for though the distinction is valid as applied to electrical action, it is not equally so as regards nervous power. A much more cogent presumption to this effect is that furnished by *time* as an element in the action through nerves. This very interesting fact of a *rate of motion*, already conjectured and vaguely estimated, has been recently

attested by the beautiful experiments of M. Helmholz on the crural nerves of the frog, which show that a space of somewhat more than *eighty* feet is passed through in a second of time. To subsequent observations of M. Helmholz we owe the further remarkable facts that the rate of motion of the nervous power in Man is more than double that observed in the frog; and that it sensibly *augments* with any augmentation of animal temperature. These experiments are so delicate in apparatus and manipulation, that few can undertake them; but their principle is one which in skillful hands may hereafter illustrate some of those variations and anomalies of nervous power, which at present perplex all our reasoning. Meanwhile the fact ascertained of the propagation of power in definite time, brings us to the conception of a physical force, like to those which act on matter through its molecular structure elsewhere in the natural world. And this presumption is strengthened when we consider the actual relation of these forces, and of electricity especially, to the functions and phenomena of the nervous system.

At this point, however, a serious doubt suggests itself. Can these functions, so diverse in nature and quality as well as degree, be due to any *single agent* of motion and power? Can we possibly predicate *unity* of any proximate cause, in actions which combine the functions of the several senses; voluntary and involuntary muscular contractions; — the nervous influence directed to the various secreting organs; — and the sympathies between different organs, which John Hunter well describes as the '*intercuncial office*' of the nervous system? This question will be directly seen as one of great, perhaps insuperable difficulty. As we cannot multiply agents to meet the many conditions just stated, or find adequate explanation of them in any structural differences of the conducting nerves, we can only approach a solution by looking to the diversities of organisation upon which the

nervous force acts; and by presuming, as indeed we are compelled to do, that these diversities are often of a nature to evade the most subtle research. The chemist and the microscope have disclosed to us many marvellous secrets of molecular aggregation; but they have rarely, if ever, been able to tell us of that ultimate structure, which at once defines and fulfills the various functions of life.

We have spoken of Electricity as the physical power most nearly allied, so far as we yet know, to that acting through the nervous system. We are not propounding here one of the many vague hypotheses to which electricity, from its striking and complex phenomena, has given birth; but what is a legitimate inference from the most exact and delicate experiments. These, while leaving the fact of identity still unproved, and many collateral questions yet unresolved, have nevertheless disclosed such analogies and intimate relations, as to make it probable that the forces in question are at least *mutually convertible*, in the sense we have already given to this phrase. Had we space for it, we might relate some of those wonderful results derived from the experiments of Du Bois Raymond and Matteucci, which especially favour this interpretation. We may mention, as perhaps more cogent in its conclusions than any other, one we have ourselves often seen; where a sudden and forcible contraction, *by will*, of the muscles of the forearm, evolves a current of electricity capable of passing through two or three miles of a helix coil, and creating power enough to deflect the needle of a delicate galvanometer, 50° or 60° or 70°, according to the vigour of the muscular contraction. The inference here seems direct and decisive; and it corresponds with other conclusions from the experiments of Du Bois Raymond, as to the *uniform* direction of the electrical currents pervading all muscular fibres. Yet we are still short of that certainty which science is rigid in requiring. We have reason to

believe all muscular action — perhaps every vital action — to be attended with some chemical change in the parts concerned; and every chemical change, as we know, produces disturbance of the electrical equilibrium. Changes of temperature moreover, or molecular motions, each belonging to muscular contraction, may be concerned in evolving these electrical currents. But whatever the ambiguities of the question, it is obvious that they all lie within that single circle which comprehends and connects the great Co-related Physical Forces of the universe; — a *magical circle* we may well call it, as comprising within itself some of the most profound and mysterious problems which human reason can venture to approach.

We must here come to a close; although there are still numerous topics we might bring under consideration, illustrating the efforts and results of modern science in relation to this great subject of Life on the earth. It will have been noticed how often the question of Final Causes comes before us, as a consequence, and even integral part, of these enquiries. We have already alluded to this point; but cannot conclude without reverting once again to a principle of reasoning which it is of signal importance should be rightly appreciated in the interpretations it affords. A misplaced sophistry, fortifying itself by a single phrase of Lord Bacon's of doubtful meaning, has sought to impugn this method and the conclusions thence derived. It cannot be done. Such reasoning is an integral necessity of our mental constitution. The fallacy lies here, as so often elsewhere, in imputing to the use of the faculty what belongs to its abuse; since, if using that caution which the nature of the subject inculcates, we may safely and profitably employ it as a guide in research, as well as an exponent of discovery, in every part of the great domain of created life.

POSTSCRIPT.

The foregoing article was published a year before the appearance of Mr. Darwin's remarkable work on the 'Origin of Species.' Whatever be thought of some of the conclusions at which Mr. Darwin has arrived, the value of his work as a contribution to the Natural History sciences, and as a guide to their future successful pursuit, cannot be too highly estimated. Nor is it possible to speak too strongly of the candid spirit manifest throughout this volume; leading its author to anticipate objections and acknowledge all difficulties; and to state, even perhaps beyond his own belief in them, the conclusions to which his doctrine might be liable, if carried to its extreme inferences.

Thinking it well that the argument on the other side should be fully and fairly weighed, I have made only a few very slight alterations in the article now reprinted; one of these referring to the changes in the animal world due to the principle of natural selection, operating amidst the general struggle for existence. This principle, which Mr. Darwin has so largely and effectively used in his researches, may be considered in great degree a new path of enquiry; and one which steadily pursued by exact and patient observation, cannot fail of conducting to important results. It is certain that at some future time a revision and reform will be required of all existing catalogues of genera and species. How far the needful curtailment may carry us is yet doubtful; but there is reason to presume that it will stop very far short of anything like unity of origin, even with unlimited concession of time for the process and progress of change. An original act of creation, *in time and under*

design, being assumed in every hypothesis, the conception of any primordial unity, capable of evolving and multiplying itself into all the actual forms of life, is infinitely more difficult than that of many distinct primitive forms or types, brought into simultaneous or successive existence by one designing and creating Power. Numbers in truth (and this must ever be kept in mind), admit of no line or limitation, when applied to problems which pass so far beyond all human comprehension. Like in this to Time, similarly applied, their only boundary becomes that of Infinity.*

* Since the first edition of these Essays was printed, Mr. Darwin has published another very interesting volume 'On the Fertilisation of Orchids,' illustrating by close research the rarity of self fertilisation in this curious family of plants, and the singular provisions and varieties of structure by which the conveyance of pollen is facilitated from one plant to another. As insects are also universally the *carriers* of this pollen, we have the remarkable fact of minute and complex changes and adaptations of vegetable growth, satisfying what we may term the *instinctive necessities* of the plant, and at the same time those of the insect life by which this transportation is carried on.

HUMAN LONGEVITY.*

[Edinburgh Review, January, 1857.]

THE doctrine of M. Flourens is, that Man ought, by virtue of his natural constitution, to live for a century; and that this natural term of life is abridged only by his own improvidence, follies and excesses. Such an opinion, supported by a name of some eminence, deserves consideration at least; and this we propose to give to it, adding further what occurs to ourselves as needful to a more complete and just view of the subject.

Without citing any of the innumerable maxims and current phrases by which the love of long life has been illustrated or reproved, we may at once assume the fact that all mankind, of every age, race, and country, have a deep and paramount interest in this great question of the duration of life, and of the means by which it may best be maintained and prolonged. Such maxims and speculations come to us from the earliest records of man on the earth; — they are embodied in classical poetry, in history and romance; — they appertain alike to savage and civilised life, to the fool and the philosopher; —

* 1. *De la Longévité Humaine, et de la Quantité de Vie sur le Globe.* Par P. Flourens, Membre de l'Académie Française, Secrétaire perpétuel de l'Académie des Sciences, &c. &c. Deuxième Edition. Paris, 1855.

2. *On the Decline of Life in Health and Disease.* By B. Van Oven, M.D. London, 1854.

3. *Records of Longevity.* By Thomas Bailey. London, 1856.

and are common to every country and clime, from the arctic circle to the equator.

There needs no argument to prove that this must be so; and that the feeling is justified by being natural and inevitable. The word *Life*, when thus used to express the totality to every man of his present being, is itself of deep significance. While marking the longer or shorter space which each one occupies in the endless line of time, it includes those many wonderful changes of mind and body — those diverse yet continuous stages of existence — by which, without forfeiture of personal identity, childhood, manhood, and old age are all included within one span. Philosophy in every age has been occupied and perplexed by this great problem of the origin, progress, and end of life. Metaphysicians and moralists alike have lost themselves in the enquiry. Physiologists and physicians, by taking other routes, and noting the close connection of vital and physical laws, have seemed to approach nearer to its solution; yet all are met in the end by barriers which no research can surmount, and upon which speculation wastes itself in words without meaning.

Look, as a single case, to that profound problem to which we have just referred; — the preservation of unity of consciousness, under the successive natural changes of state, and the numberless accidents and strange fluctuations which compose the life of man. The phrase of Rochefoucauld, '*On est quelquefois aussi différent de soi-même que des autres*,' is a feeble and superficial expression of those diversities of condition which occur in each single being, between the cradle and the grave. Yet the line of personal identity is kept entire, though thus knotted and tangled in every part of its length; — though feelings are altered and memories have passed away. If reason cannot reach these things, faith may find in them some index to a higher identity beyond the term of life on earth.

Look again at that which seems to make the greatest breach in this unity of being, yet is itself an integral part of life, and necessary to it — the wonderful phenomenon of Sleep. If called upon to name that part of our nature, which is at once most marvellous in itself, and most prolific of conclusions beyond, we could not hesitate to find it in this great function, so familiar to our experience, so obscure to our philosophy. When Sir Thomas Brown describes sleep as 'the brother of death, which extracteth a third part of our lives,' he quaintly but strikingly denotes the wonderful fact of this periodical intermission of ordinary life; during which the senses cease in great part to have relation to the world without; and the mind, barely conscious of its own identity, works in a vague succession of images and associations; — the shadows sometimes of prior events, sometimes the seeming creation of the very act of dreaming, and traceable to no reality of waking existence. Scarcely can we abate our wonder at this phenomenon of our nature, by placing what we believe to be its true theory before us; viz., that sleep is not one, but an unceasing variety of states; — passing through every stage and degree of change from perfect wakefulness to the most complete suppression of all external consciousness; — varying also at every moment in the degree in which each particular sense and function of life is submitted to its influence.* All these more special conditions of sleep do rather enhance the wonder and the mystery of a state, which thus occupies and engrosses a full fourth part of human existence on earth; — not less than a third, if we take infancy and old age fairly into the calculation. The sleep and various states of semi-consciousness produced by mesmeric

* This view of Sleep as a succession of ever-changing conditions, I have strongly urged in my volume on Mental Physiology, as the only one accordant with truth, or capable of expounding the phenomena, mental and bodily, of this mysterious function of life.

or other unwonted means, we look upon with awe and amazement; forgetting, in their familiarity, those equally strange phenomena under which we periodically pass this portion of our existence.

We have hitherto been speaking of Life in its larger physiological sense. We now come to that more especial view of it indicated by the title of the volume before us; in pursuing which subject however, it will still be needful to recur occasionally to the more general theory for aid and illustration. The questions regarding human longevity are far too complex to be submitted to any single solution, or separated from the elementary consideration of life itself.

The name and repute of M. Flourens in the scientific world might well warrant some high expectations of a work coming from him, and bearing this title. We are bound to say that these expectations are in no way fulfilled by the treatise before us; the greatest merit of which is that it is not long, and not otherwise tedious than through its loose and inconsecutive reasoning. The result he seeks to establish as to human longevity we consider to be unfounded; and his arguments on behalf of it vague and unsatisfactory. Of this first part of his work we shall speak more in detail hereafter. Meanwhile we may content ourselves with a very cursory notice of the latter half of the volume, indicated in the title-page by the phrase '*De la Quantité de Vie sur le Globe.*'

Though aware that this phrase is borrowed from Buffon, we still claim the right to object to it here, as an affectation of higher philosophy and originality than really belongs to this portion of M. Flourens's work. The doctrine of Buffon, upon which his own views are founded, is this; — that taking all created beings into account, the total quantity of life on our earth is always the same; — that the Creator has brought into being an incalculable number of living organic molecules, indestructible and common to all forms of organic life, the

material of generation, growth, and duration of existence; — that death, while it destroys and dissolves individual forms or lives, does not annihilate these molecules, which pass into other forms, giving and maintaining life as before, and being always the same in total quantity on the globe. This is one of the many fruitless hypotheses common to every age; easy to construct — difficult absolutely to refute or deny — impossible to prove. The *molécules organiques vivantes* of Buffon, like the *plastic nature* of Cudworth, are an effort to shelter penury of knowledge under the garb of scientific language. Though the higher genius of Leibnitz gave somewhat more of philosophy to his *monads*, yet essentially the attempt and the failure are the same. Life may be defined, more or less justly, through its functions. In its elements, no reason or hypothesis can reach it.

M. Flourens, however, while professing admiration of Buffon's genius, and acquiescence in the hypothesis as to the equal and constant quantity of life on the globe, places this doctrine on a basis of his own, which we may briefly give in his own words:—

> Je n'étudie *la vie*, ni dans les molécules organiques, ni dans les monades. J'étudie *la vie* dans les *êtres vivants*; et je trouve deux choses: la première que le nombre des *espèces* va toujours en diminuant, depuis qu'il y a des animaux sur le globe; et la seconde que le nombre des *individus*, dans certaines espèces, va toujours au contraire en croissant; de sorte que, à tout prendre, et tout bien compté, le *total de la quantité de vie*, j'entends le total de la quantité des êtres vivants, reste toujours en effet à peu près le même.

No evidence for this doctrine is known to us, and assuredly none is furnished by our author to justify its enunciation as a special discovery. It is very true, as M. Flourens states, that various species of animals — some of them, as attested by their bones, of gigantic size — have become extinct during what may be called the existing epoch in the history of the

globe; — that others are probably in progress towards extinction; — and that no new creation is known within this period, of animals of equivalent size to replace those thus vanishing from the earth. It is also true that many of the domesticated species, serving to the uses of man, have been largely increased in numbers in effect of the increase of human population on the globe. But these things, which are *true*, are not *new*; and the doctrine derived from them — that a balance is struck between the two opposed conditions, and that the total quantity of life, or of living beings, remains always nearly the same — is one wholly unsupported by the premises. Its wording, in fact, betrays the author's hesitation as to its truth. The '*à peu près*' is a great discounter of realities in science, as in most other things.

It will be obvious indeed to all who care to reason on the subject, that we have no knowledge, or means of obtaining it otherwise than by vague approximation, as to the total quantity of life on the globe, or the relative quantity at different periods. Such phraseology then, except as denoting mere hypothetical questions, cannot rightly be admitted into scientific language; seeing especially how little we are able to estimate numbers or *individualities* of life in any of the great classes of the animal kingdom; — how impossible it is to conjecture them in the multitude of those lower forms which we reach only through the eye of the microscope. Nor in fact can any such conclusions as those put forward by M. Flourens be accepted, as long as doubts exist as to the proper definition of species, and the possibility of their change or transmutation in long periods of time. We may not acquiesce in these doubts, but the question is one fully open to future enquiry.

Dismissing however this subject, which it is not necessary to pursue further, we come to the main topic of M. Flourens's

volume — the longevity of man. We wish to deal fairly with his doctrine, and shall state it as clearly as we can. But here again we have to complain of the loose and desultory character of his reasoning, broken by numerous citations from other writers, poets as well as physiologists, and many of them little fitted to serve as authorities in a scientific treatise. We have been accustomed to look into the pages of Molière, Voltaire, and La Fontaine for satire upon human life, and not for sober reasoning upon longevity.

M. Flourens propounds his main question in these terms: — 'Quelle est la durée, naturelle, ordinaire, normale, de la vie de l'homme?' And he instantly replies to this question by a passage from Buffon, which he takes as the text and authority for his own views. 'L'homme qui ne meurt pas de maladies accidentelles, vit partout quatre-vingt-dix ou cent ans.' Though we might comment on the tautology of *naturelle* and *normale* as applied to the term of life, we can find no other fault in this manner of propounding the theme. In adopting the conclusion of Buffon, he follows the same train of reasoning to it. He affirms that the duration of life depends neither on climate, nor food, nor race, nor any external condition; but has relation solely to the natural constitution and intrinsic vigour (*vertu intrinsèque*) of the vital organs. Regarding everything in the animal economy as submitted to fixed laws; — that every animal species has its determinate shape and size, its particular time of gestation and period of growth; — he infers that the natural duration of life must be equally definite for each species, and open to determination. Still following Buffon at each step, M. Flourens accepts his doctrine that this measure of life is to be found in a certain proportion to that of complete growth, as well in man as in other animals. He differs only as to what may be taken as the term or limit of this growth. Buffon, naturally enough, makes *stature* his index;

and assuming the average period of growth in height in Man to be about sixteen years, he takes six or seven periods, the multiples of this time, to express the natural duration of human life. He fortifies himself in this result, by noting a certain proportion of time of growth to the length of life in other animals, as the horse, dog, stag, &c.; but neither numerically nor otherwise does he claim for his doctrine the absolute exactness of a physical law. 'The whole duration of life may in some measure be calculated by that of the period of growth. Man, who is fifteen years in growth, may live six or seven times that period of time.'

M. Flourens is bolder in his conclusions, and in the same degree farther removed from truth. He adopts as the term or limit of bodily growth (*accroissement*) the complete union of bones at their Epiphyses (an expression we shall speedily explain), and alleging this consummation of growth to occur in man at the age of twenty; and in certain other animals at other ages, but in each respectively the fifth part of the term of life, he at once multiplies by 5 the 20 years of human growth, and pronounces 100 years to be the natural period of human existence. We produce this view in his own words: —

> Buffon says that every animal lives about six or seven times as long as it is in growing. On this supposition the relation would be as 1 to 6 or 7; but the real relation of the period of growth to the duration of life is as 1 to 5, or nearly so. Man is 20 years growing, and he lives five times 20 years, or to 100. The camel is 8 years growing, and he lives to 40: the horse 5 years growing, and he lives to 25; and so on to other animals. We have thus then, at last, an accurate criterion which gives us with certainty the period of growth. The duration of that period gives us the duration of life.

The argument, thus put, is more summary in manner than satisfactory in substance. We doubt much whether this period of epiphysis, or completion of bony union, has been

determined in a sufficient number of animals, and with sufficient exactness, to serve as a basis for numerical results. We believe further that the relation of this period to the normal duration of life in different animals, is nothing more than that general proportion which every successive period bears to its antecedents and consequents; rendering each in some sort a measure and index to the rest. What is called *epiphysis* is a very limited phenomenon of growth; and though seemingly the last in the series of osseous developements, cannot be admitted as an epoch in life, or as having any important relation to other structural changes. We dispute then, altogether, the right of M. Flourens to take it as his basis; and by applying his multiple of five, to make it tally with what is evidently a foregone conclusion of his own as to the length of life. This conclusion is not logically attained, and is manifestly contradicted by facts.

He appeals, however, to actual experience on behalf of his doctrine that one hundred years is the natural life of man; and that its curtailment below this normal term is the result of those errors and excesses in the manner of living, which impair the organs and produce premature decay. And his argument here mainly lies in the citation of those cases in which life has been prolonged far beyond the average limit; — instances often of exaggerated or doubtful kind, but yet numerous and authentic enough to be admitted as positive facts in the natural history of man. While justly sceptical as to examples which go beyond our own experience, we cannot dispute the statements coming to us from various sources, from different countries and periods of time, that human beings have occasionally reached, and now and then exceeded, the extraordinary age of 150 years. In our own country, for example, though we may put aside as unproved the case of Henry Jenkins, alleged (chiefly on his memory of the battle of Flodden Field) to have lived 169 years; and

regard with doubt that of the Countess of Desmond, whose age is recounted at 148; yet we cannot equally reject the evidence as to the 152 years of Thomas Parr's life, accredited as it is by the testimony of Harvey, who examined his body after death, and states that there were no obvious reasons why he might not have lived yet longer, but for those changes in his habits of life which followed his removal to London and to the kitchens of the palace.

Instances of this extraordinary kind, indeed, are fully admitted by some of the most eminent physiologists; and Haller and Hufeland respectively, after citing several especial cases of life exceeding 150 years, affirm it as probable that the organisation and vital forces of man may be capable in some cases of reaching 200 years of age. No proof, however, is given by them of such age having ever been attained; nor is there any record of it, except in one or two instances, so utterly without attestation that they must at once be discarded. We note one of them below, simply to show how loose is the evidence often received on these matters.* But we cannot refuse belief to a certain proportion of cases in those Registers of longevity which, comprising many thousand instances, must contain some average of truth, however difficult it may be to discriminate or define it. Dr. Van Oven, in tables which he has drawn up with great diligence, gives seventeen examples of age exceeding 150 years. In another of the volumes before us (the 'Records of Longevity,' by Mr. Bailey) we have a catalogue of three or four thousand cases of longevity verging closely upon, or exceeding 100 years, and several of them reaching 150 years. Without seeking to impeach the good faith with which these tables are constructed, we cannot but feel the great want of any

* This case is derived from a parish register in Somersetshire, where the record appears of the 'burial, in Dec. 20, 1588, of Jane Britton, a maiden — as she affirmeth at the age of 200.'

exact or sufficient evidence belonging to them; a fault which no present research can now repair. Still we are bound to admit some, even of the extreme cases, as authentic; and to presume an increasing proportion of others, which, though lower in the scale, do yet greatly transcend the average term of life. We shall have occasion afterwards to refer to these more especially. At present it is enough to state that we have sufficient proof of the occasional prolongation of life to periods of from 110, to 130, or 140 years; — cases which, thus far authenticated, we must necessarily take into view when dealing with this question of human longevity. But in so doing, we are called upon to submit them all to the great general law of averages, and not to propound them, as M. Flourens does, as exponents of the natural capacity for life in man. We might just as reasonably assert that six feet is the natural stature, because some men have reached the stature of eight, or even nine feet;— or on the other hand, that four feet is the normal measure, because Count Benyowsky and the American Tom Thumb were dwarfed down to two and a half or three feet;— or yet further affirm that fifteen stone is the natural weight of the species, because Daniel Lambert, and some of his brethren in obesity, have nearly doubled this weight. The real fact is, that these anomalies, either of excess or deficiency, occur in every part of the physical structure of man, as in every part of the world of nature that surrounds us. Exceptional however to the general laws which govern the animal creation, they are continually checked and controlled by these laws. They cannot pass certain limits without bringing into action fresh physical causes, tending to destroy the anomaly, and to restore that particular condition, which, as far as we can see, is specifically annexed to every organism in the natural world.

Here then we find the value and import of the great law of averages, to which we have just alluded. Almost it may be

called a new method of research, though now among the foremost in contributing to the extension and exactness of human knowledge. It is curious, but true, that the understanding of this particular mode of reaching truth was never fairly attained by the philosophers of antiquity. Some practical application of it is, indeed, next to inevitable in the most common processes of human thought and enquiry. But the principle was never fully recognised or converted to scientific use; — an intellectual anomaly having close kindred with another still more singular default in the ancient philosophy; viz., the want of any right appreciation of *experiment*, as the most certain and powerful instrument of scientific research.

Modern science has fully acknowledged, and carried into active use, these two great methods; mutually dependent in every part and principle of their application. The law of averages, indeed, has acquired of late a wonderful extension and generality of use; attaining results, from the progressive multiplication of facts, which are ever more nearly approaching to the fixedness and certainty of mathematical formulæ. Every single observation, and every new fact added, comes into contribution to these resulting truths. Phenomena, seemingly the most insulated, and anomalies the most inexplicable, are thus submitted to laws which control and govern the whole.

Many of our readers must be aware how largely this doctrine of averages has been applied, not merely to physical phenomena, but even to the social and moral conditions of man, as the highest tenant of that globe on which his destiny is cast. Under the auspices of Quetelet and others of his school, aided by the facilities of intercommunication now existing between the different regions and races of the earth, statistical knowledge thus attained has taken a high place among the sciences, and promises for the future a powerful influence on the welfare of mankind.

Previously, however, to this more scientific direction of the doctrine of averages, it had already received what we may call a *mercantile application*, in relation to the very topic now before us; viz. the estimate of human longevity. A new and vigorous traffic has sprung up within the last eighty years, of which the duration of life is the subject and basis. We need not enlarge here upon the principle or history of Life Assurance as a branch of actual business. Originating in England, it is here especially that it has grown and diffused itself so as to become an essential part of our social policy; — a natural, if not necessary, result of those complex relations of property and family connections, which are created by high civilisation, personal freedom, and political security. And though partially defaced by certain evils inseparable from all human institutions, we may regard the system as one conducing largely to the interests and welfare of the community. As interpreters of the averages of life, and of the various conditions affecting its duration, Insurance offices in their present extension have become our best guides; and their tables and calculations, though modified materially of late years, do singularly expound that uniformity of results which arises out of these numerous and extensive records of age and death. Mathematics have lent their aid to the calculation, and given to it many of the conditions of an exact science.

Still more important documents as to human longevity are those furnished by the English Decennial Census, and the annual reports of the Registrar-General. In these the results are derived from the total population of the kingdom; and so admirably recorded and classified as to afford not solely numerical conclusions respecting the several periods of age attained, but also much and curious knowledge as to the circumstances and conditions which affect the average duration of life in different classes. Those who desire more detailed information on this subject cannot do better than

consult these valuable reports. They possess the further advantage of being readily brought into comparison with the corresponding tables, more or less perfect, furnished from other European kingdoms and from the United States; many of which tables are in fact contained in the volumes of English registration.

We shall have occasion to allude to some of these reports hereafter. But meanwhile we may state, as the result from them, that they utterly refute the doctrine which forms the pith and purport of M. Flourens's volume. Such formal refutation was in truth hardly needed of an opinion contradicted, as we have before said, by the common experience of mankind of every age and country. A hundred years is not, and has never been, the natural or normal age of man. No deviations from a life of nature, — no excesses of luxury, or labours and privations of poverty, — will suffice to explain the disparity between the doctrine in question, and the facts as they stand in face of it. M. Flourens dwells with complacent detail on the old and familiar instance of Louis Cornaro, the Venetian self-reformer; — a notable one, doubtless, if we may trust to its correctness in all particulars; but bearing marks of exaggeration; and at best but an individual case, where the argument needs a multitude. If seeking for any causes likely to affect and alter the term of life on a large scale, we should rather expect to find them in the extraordinary diversity of physical conditions to which mankind are exposed; and especially in those conditions which belong to the extremes of climates in different parts of the globe. But M. Flourens himself rejects these causes as of little or no influence upon what he assumes as the normal term of life; and though we dispute his doctrine on the latter point, we agree with him so far as to believe that the external physical conditions to which man is subjected, have less influence than might be supposed upon the average duration of existence.

Adaptations, partly of bodily textures, partly of aliment — in each case the effect of these physical conditions — come into action here, and restore that parity which appears to be the natural law for the species.

But it may be asked,—What then, rejecting this doctrine, is the true natural term of human life? Or is there any which can be strictly designated as such? The question is a simple and definite one. The answer cannot easily be rendered so. It might seem probable indeed *primâ facie* that in the case of Man — single in species and presumably derived from a single stock — there should exist some middle term of natural age, marking the destined duration of his being on earth, apart from all those incidents, physical or moral, which crowd upon and affect his existence. But these incidents are so numerous and varied, so obscure often in their origin and progress, yet so constantly blending themselves, as we shall see hereafter, with the hereditary constitution of families and communities, that all sagacity is at fault in seeking to deduce and strictly to define such natural term of life. The most copious and accurate registers fail us here; and we are forced to regard it in some sort as an abstract conception incapable of being expressed, otherwise than approximately, by any simple number. If called upon to state this approximation, we might perhaps seek to rest it on the venerable record of '*three-score years and ten*;' with a leaning, however, to the belief that this is rather *below* the true mark. Blumenbach, a great authority on such subjects, rated the period at eighty years. But under no circumstances can we admit the *Century* of years which M. Flourens has pleased himself by assigning to life; or allow the force of the arguments by which he seeks to substantiate his doctrine.

Dismissing then this particular question suggested by the work before us, we may invite our readers to other parts of the interesting subject of human longevity. And first there

comes into consideration the curious topic of *comparative longevity*;—comprising questions of nations and races, civilised and savage;—of successive periods in the history of the world;—of families as well as individuals;—of sex, occupation, climate, food, and all other conditions pertaining to human life. Volumes would be needed to follow these matters into detail. M. Flourens touches upon them so slightly and vaguely, that no aid is to be gathered from his treatise. In our limited space we cannot bring them before our readers otherwise than by selecting a few prominent conclusions, serving to illustrate the main objects of enquiry, and the methods best fitted for attaining them. Any attempt to go beyond this would be perplexing and futile.

It is natural to look first — and it cannot be done without interest—at the records of longevity in former ages which may be brought into comparison with those of our own time. We have already indicated as the chief attainable results of such enquiry, the general duration of what may be considered the *completed life* of man, and the extreme cases of age stretching beyond this mean term. For obvious reasons we omit all reference to the length of antediluvian life, as we receive it from the Scriptures. We could say nothing new towards the solution of this question; depending, as it does, upon conditions and a state of the world to which no present knowledge can apply. We turn with more assurance to another record, (of later time, but also bearing in its superscription the great name of Moses), which, in defining the life of man at *three-score years and ten*, affords a measure corresponding closely, as we have already seen, with the every-day experience of our own age.* In the beautiful

* It is worthy of remark, though doubtless familiar to many, that from the time of Noah to the days of Moses and Joshua, the record is one of *successive and gradual decrease* in longevity. Joshua '*waxed old and stricken in years*' some time before his death at 110 years.

passage of this psalm (so admirably translated by Lord Bacon), we have in a few words the touching picture, true to every time, of the decrepitude and other ills which affect life when prolonged beyond the average term the Creator has assigned to it.

The records of ancient Egypt, Assyria, and Persia, though not expressing the fact to us in such positive forms, yet concur in furnishing the same general inference. The several periods of individual life are denoted as we now denote them; and generations succeed one another, as far as we can interpret the ancient monuments of the dead, under an equal and similar law. The pyramids were the tombs of monarchs who, as an old writer says, 'astonished Heaven by their audacities,' but whose term of existence would seem to have been strictly commensurate with our own.

As we descend to the days of Greece and Rome, the notices derived from history and other kindred sources become more explicit and particular. The result we may affirm to be the same; testified to us both in the mean term of life as we have defined it, and not less remarkably in those deviations by excess, which in themselves furnish a sort of reflex proof as to the average; — a manner of verifying the mean number more valuable than on first sight might appear. Though we still cannot authenticate particular facts in these periods with the same assurance as by the statistical tables of our own time, yet neither Greeks nor Romans were wanting in methods of assigning exact date, even to the events of private life, through the popular and political institutions which are so deeply embedded in their history. The Olympiads and public festivals of Greece, and the Consular Fasti of Rome gave time, as well as name, to numerous family and personal occurrences. The '*calidus juventâ consule Planco*' of Horace, is a familiar instance of the mode of dating events through this greatest and most lasting institution of the

Roman State; and we know it to have been applied to that record of births which is essential to all evidence regarding longevity. We may refer, as an example of the completeness of some of these documents, to the account Pliny gives us of the Italian census instituted in the time of Vespasian; in which, to some extent at least, the classification by ages seems to have been conducted on the same plan as that we now follow. To this author we are indebted for much information on the subject of longevity; and the caution he applies to such instances as are presumably fabulous, or dependent on other modes of estimating years, is some security for the exactness of the cases which he admits without such suggestion. They are probably as authentic as the similar records of any modern people two or three centuries ago.

Premising this, we may mention a few of the particular instances of longevity belonging to those times; and such especially as are associated with the eminent names of antiquity. The first case, indeed, that of Epimenides the Cretan (the subject of the famous example of the circulating syllogism), we must regard as very doubtful; the authorities for his alleged age of 167 being exceedingly slender. The Greek philosophers generally, however, of all sects and tenets, make fair show on the list; and under better evidence of authenticity. Zeno is stated to have lived 102 years; Democritus, 104; Pyrrho, 90; Diogenes, 90; Hippocrates, 99; Plato, 82; Isocrates, 98; Gorgias, the master of Isocrates, 107. But for the cup of hemlock, and the sword of the Roman soldier, the 70 years of Socrates and the 75 years of Archimedes might well have reached the same high class of longevities. The old age of Sophocles, 90 years, is associated with the touching anecdote of his recitation of verses from the Œdipus in Colonus, in proof of his sanity of mind at that age. The lofty lyric genius of Pindar was not lost to

his country until he had reached 84 years. Simonides wore his elegiac laurels to the age of 90.

We wish we could settle a much disputed question, by assigning a period and time of life to that greatest of all the Greek poets, whose name alone lives, but will ever live through every age of the world. Strange it is that the fame of Homer, thus immortal, should be dissociated from any distinct record or time of birth. Still stranger, perhaps, that his *individuality* should have been called into question by the hard and technical criticism of our own day.

We might go on to cite numerous instances of eminent longevity from the Roman annals; many of these on the authority of Cicero himself. But we will confine ourselves to a few cases of female longevity, of less historical weight, though curious in other ways. Terentia, the wife of Cicero, lived to 103; Clodia, the wife of Ofilius, to 115 years. Two remarkable actresses stand on the list; one of whom, Lucceia, is stated to have performed as *Mima* for about 100 years; the other, Galeria, was brought back to the stage, during games celebrated in honour of Augustus, in her 104th year, and 91 years after her first appearance before the Roman public. Pliny affords us a similar instance from the other sex, that of the dancer Stephanio (*qui primus togatas saltare instituit*), who having danced at the secular games of Augustus, performed again at those of Claudius, 63 years later, and lived still some time afterwards.

The Census, already mentioned as instituted by Vespasian, furnishes some results as to longevity singular enough to make us more than doubtful of their truth. The instances given by Pliny are taken exclusively from the region between the Apennines and the Po; and upon the record of this census (which he himself calls *res confessa*) he enumerates 54 persons who had reached the age of 100; 14 of 110 years; 2 of 125; 4 of 130; 4 of 135; and 3 of 140 years.

In the single town of Valciatium, near Placentia, he mentions 6 persons of 110; 4 of 120; 1 of 150 years. These round numbers convey suspicion as to the reality of the ages in question; and the whole statement, drawn from a district by no means noted for its salubrity, is so much in excess of any similar record in other countries, that we must repeat our expression of entire disbelief. If true, it could only be solved by supposing a remarkable aggregation of cases of hereditary family longevity, through intermarriages in the same province. Nor can we draw from these, or other memorials of ancient longevity, any argument for believing that the mean duration of human life was ever above that which belongs to the period in which we now live.

From the question of comparative longevity in ancient and modern times, we come to that of races of men; — an enquiry subordinate in some sort to the higher question, whether we must regard all races as derived from a single primitive stock? or whether, to explain the remarkable physical diversities which we see, it is needful to suppose the original creation of more than one type on the earth? This question is one which has been keenly agitated of late years. For ourselves, we assent to the former belief, or that of unity of type and origin. We find evidence for this in the very multiplicity of existing varieties; and in the manner in which they graduate into one another. Of abrupt lines of demarcation there are none; and we follow the Negro into the Caucasian races through every step and stage of variation. This argument may not be positive; but it at least answers the objection from the disparity of the extreme cases.

We must not, however, be seduced from our subject by this higher enquiry, curious and important though it be. It is enough to recognise here that Man forms, in every proper sense in which the term can be defined, a single and separate species in the animal creation. The varieties or

races of this species are all related by common conditions of reproduction,— of structure and functions of the skeleton and internal organs, — and of the aliment appropriate to growth and maintenance. To these varieties thus far identified in character and origin, our present question of comparative longevity applies. Without referring to those several divisions into races, which historians or ethnologists have adopted, we may at once take the extreme instances of the Negro and of the people of Northern and Central Europe, as including all intermediate cases. And here again, as in the question regarding the comparative longevity at different periods of time, we are led to the conclusion of that general parity, which the conditions just noted might lead us to expect. We cannot, indeed, go for facts to parish registers of Bornou, or to Statistical Societies of Soudan; but from the registries of our West Indian Islands, and from the decennial census of the United States, we obtain information bearing closely on the question before us. We must not say *deciding* it; since the results, if indeed certain, would show a very singular superiority in length of Negro life over that of European origin. In 1840, for instance, when the population of the United States was about 17 millions, of which 2½ millions in round numbers were negroes, the Census gave 791 as the number of *whites* above 100; while of *slaves* the number of those above 100 is registered as 1,333; of *free negroes* as 647. In 1855, we find from the Census, that 43 persons died in the United States above 100; the oldest white male at 110, the oldest white female 109; the oldest negro man 130, the oldest negro woman 120, both slaves.* From

* While correcting this sheet for the press, we see in an American paper the statement of the death, at Rummerville, in Virginia, of Mr. Craft, a servant of Washington in the war of 1756, at the age of 128 years; leaving two sons living, the youngest 97 years old. Other instances of great longevity are noted in the same family.

Professor Tucker's analysis of the American census from 1790 to 1840, published a year ago, we derive the strange result, if true, that the chances of living above 100 are 13 times as great among the slaves, and 40 times as great in the free negroes, as in the white population of the country.

These results however, as we have just hinted, are too anomalous to be readily accepted. Scarcely half a century has elapsed since the importation of slaves from Africa was prohibited by law; and we may therefore safely presume, that most of those whose *alleged ages* exceed 100, were of African birth; a circumstance which bars *in limine* all certain conclusions on the subject. Even with respect to those born in the States, there is much likelihood of faulty registration, added to by the frequent transference of slaves from one estate to another. And yet, further, we have to consider here the habits of the negroes themselves; their curious inaccuracy as to all matters of numbers; and their proneness to exaggeration, especially when by applying this to age, they may hope to obtain some interest in their fate, or mitigation of their labours. Professor Tucker goes farther, and speaks of the temperate and easy life of a large part of the slave population as adding to the chances of longevity. We should gladly believe that it was so; but the much larger proportion of centenarians among the free blacks weakens the force of the inference.

For these and other reasons we cannot draw just conclusions from the American census; while the general evidence from other sources (confirmed by personal enquiry we have ourselves made in the country) leads to the belief that the average longevity of the Negro and European races differs but little in amount. The extreme cases of longevity in the former, furnished us from our own West Indian Islands, closely tally with those recorded in the registers of the white

races of Europe; and, as we have already said, these extreme cases form a sort of index to the average sought for.*

We have not space to pursue this comparison in detail through the several races and nations of modern Europe and Asia, though the materials we now possess are ample for the purpose. Of these races, variously commingled indeed in their present nationalities, the Teutonic and the Sclavonic are the most considerable; derived, as modern philology teaches us, from a common Asiatic source, yet with wide separation by intervening time. European Russia best expounds all that relates to the Sclavonic race. In the subjoined note we give a few particulars, drawn from the registers of this empire, and also from those of some of the Teutonic nations of the north of Europe.† They confirm the result of general equality, both as to the medium duration of life, and as to longevity by excess. The medium annual mortality varies materially indeed in different countries, still more in detached localities; but such diversities

* We have attempted, but without success, to obtain some distinct evidence as to the comparative longevity of mulattos, quadroons, &c. The common belief is that they are short lived, and that such breeds soon cease to be prolific. But more and better attested details are required before we can reach any certain conclusions.

† For Russia, the returns of 1842 are before us. From these it appears that the mean annual mortality in that empire is fully 3½ per cent. (in the provinces which include the basins of the Wolga, Don, and Dnieper, considerably more), a very high ratio compared with the 2¼ per cent. of England; but in some part explained by the great mortality of infants in Russia. These tables do not give detailed specification of ages above 90; but they record for several years the number of deaths of *males* upwards of 90. giving a mean of more than 5,000 for each year, or probably 10,000, had females been included. This stands in large proportion to the population; but as at the date of 90 years before these returns, there was no system of registration in Russia, their accuracy admits of much doubt. In Austria, including Lombardy, in 1842, 446 persons died at ages above 100, out of about 460,000 deaths.

In the Prussian States, in 1841, 786 males and 890 females died at ages upwards of 90. In Norway, in 1845, when the population approached 1,200,000 there were found to be 19 males and 22 females above 100. We could have wished for some specification of the actual ages here, Norway being reputed to afford examples of extreme longevity.

often belong to particular periods of life only (as that of infancy), and affect more partially than might be supposed the result with which we are here mainly concerned.

We have already spoken of the excellence of our recent English registration, as attested by the volumes annually published. Though they afford us no present cases of longevity equivalent to those of Jenkins and Parr, they indicate a medium duration of life, and a proportion of lives above 100, at least equal to what exists in any other country. Taking two recent years as a brief illustration, we find in 1852, when the population of England and Wales was 18 millions, there died 35 males above 100 years of age, the oldest 105; — and 53 females, of whom three reached 106, one 107, and two 108 years. In the following year, the register tells us of the deaths of 31 males, and 62 females, above 100; — the oldest male 109, the oldest female 110 years.* We may add regarding England, that the low rate of medium annual mortality (not exceeding 2¼ per cent., and much below that of most European nations) expresses causes which must undoubtedly have effect in multiplying the cases of great age. As we have already said, the influence of these causes is limited by various considerations; but we cannot reasonably exclude it; or deny that there may exist from this source certain mean differences of longevity in the several races and nations of mankind, as with respect to stature and other marked features of bodily conformation. The evidence is not yet sufficient to define these differences, or the precise conditions producing them. The reasons, however, already urged lead us to believe that the disparity, when ascertained, will not be found considerable in amount.

In pursuing this question of human longevity, we pass

* The returns recently issued for 1860, show that in that year 22 men and 47 women died, who had reached, or gone beyond, 100 years of age. One woman, in Glamorganshire, reached 111 years. Two men are recorded as having each lived to 107 years.

from races and nations, where large averages cancel more or less completely all subordinate inequalities, to the lesser divisions of families and local or limited communities, where new causes come into action, no longer neutralising each other in their general results. All who rightly comprehend the law of averages will see at once that this must be so. It is impossible to particularise the many causes which affect the health and life of man in various localities; but the subject of longevity in families connects itself with one of the most curious questions in human physiology — that of the hereditary transmission of physical qualities and peculiarities from parents to offspring. Every one is familiar with this fact in the case of other animals; especially in those domesticated by man, and made more useful to him by the varieties thus produced. We cannot affirm that the capacity for change by such hereditary transmission, is as great in man himself; for except in the instance of the gigantic Prussian grenadiers, and possibly in the usages of some savage tribes, we are not aware of any attempt distinctly made to test this question. But in one form or other the fact is familiar to the observation of all; subject, indeed, to the anomalies which beset every part of this great mystery; yet exhibited in such numberless ways, on mind as well as body, as to show its mighty influence on the destinies of man. The most minute peculiarities of external feature, as well as the grosser conditions of stature and bulk, are capable of being thus transmitted; and we cannot doubt, upon pathological observation, that the internal organs also — possibly even that wonderful fluid which circulates through and ministers to all of them — are subject to the same influence derived from one generation to another. The bearing of this influence on the formation of national diversities of feature and character, is a most curious collateral topic, but its discussion would be out of place here.

What, however, clearly pertains to our subject, is the fact of longevity being hereditary, and running in particular families and lines of descent. Where the organs, serving to the great animal functions — respiration, circulation, nutrition, and secretion — are sound, and conveyed as such from one generation to another, an average prolongation of life will occur as the natural effect. All this is fully confirmed to us by common observation. Every group of tombstones indeed tells a true tale, in this respect, of what lies underneath. Before the Titanic power of steam had given the speed and vehemence of the race-horse to our manner of travelling, we can remember the time when we used to loiter through the country churchyard while horses were changed, or dinner prepared, at the road-side inn. Here, in its simplest but most touching form, may well be learnt the truth of which we are speaking. On one family group of gravestones are recorded the many early deaths which give evidence of feeble or diseased family constitution; — while another group, close at hand, tells in its dates the history of sound native temperament and prolonged age from parents to offspring. Considering the various collateral influences ever at work, we have often been surprised by the uniformity of this result. But these external influences are in fact continually tending to restore the balance; and do in the end retrieve that average in which all anomalies and inequalities finally merge. Intermarriage among different families, in successive generations, is obviously the natural provision against such inequalities. They sometimes, however, continue long; and occasionally assume very singular and morbid aspects; where, from some cause of local or social limitation, intermarriages are confined to a small community without due admixture from without. This natural correction then, very little aided by human prevision, is a *providential one*;— illustrated by analogies in other parts both of the animal and vegetable

kingdom; but a mystery in itself, like all that belongs to the transmission and interblending of life through successive generations.

Descending from families to individuals — the last step in the scale we have thus rapidly been following — we find the contingencies which affect longevity to multiply largely and become more obvious, than when hidden under the averages of larger numbers. One important classification, however, here suggests itself, viz. that of the Sexes. Though it would be difficult to prove the point absolutely, we think it may be presumed that the natural term of life is the same in man and woman. It must be admitted, indeed, that our own Census, in common with that of many other civilised communities, shows a considerably larger proportion of females than of males attaining 100 years. But we believe the fact to be of ready explanation, without recurring to any recondite causes. Woman drops more easily than man into the passive existence of advanced age. The pursuits, pleasures, and passions of her antecedent life are for the most part of a more tranquil kind, and do not so strongly contrast with the inert seclusion of later years. The expression of a French writer '*Peu de gens savent être vieux*,' has much closer application to one sex than the other. The incidents of childbearing might seem to lie on the other side. But these belong to, and affect, an earlier period of life; and can hardly be considered as equal in influence to the external casualties which more especially beset man, even to the extremity of age. We may further remark that the cases of extraordinary longevity, which we have denoted as a sort of index to the average, are found to give a general equality of result for the two sexes.

We come then finally to individual life in reference to longevity;— a subject which cannot be dealt with except under new conditions, and a larger reference to physical and

moral causes in their influence on the animal economy of man. Of hereditary temperament we have already spoken. But apart from this, the whole of life teems with personal incidents which must needs affect, more or less, its duration. Every particular variation of health, however produced, has some definite relation, perceptible or not, to this result. The physical conditions and habits of the individual, whether those of luxurious sensuality or of meagre poverty, are in constant action here; and associated with these the various occupations, whether of choice or of necessity, which minister to the livelihood of man. No argument is needful to show the bearing of the latter both upon individuals and communities. In a manufacturing and commercial country especially, where population is crowded, and where art and labour in their every branch are strained to the utmost reach of human exertion, life becomes subject to influences which act powerfully upon it, and tend on the whole to shorten its duration. The materials and documents we possess are not yet copious and exact enough to justify more certain conclusions on the subject. That some particular occupations abridge life, by bodily confinement, privation of good air, the direct action of noxious vapours and other causes, is a fact too familiar to all. To this class of causes, acting thus definitely, must be referred in part the difference between town and country longevity; testified in England by the mean annual mortality in the larger towns being twenty-six or twenty-seven in a thousand, while that of the whole kingdom does not exceed seventeen in the same number. The whole subject is one of high interest to our social welfare, and attention is now keenly awakened to it.

Curiosity may also be directed to the question how the learned professions stand as to relative longevity? In such an enquiry it is obvious that individual cases go very little way towards its solution. With respect to the profession of

Law, we have no connected evidence sufficient to warrant a general conclusion, though many particular instances at once suggest themselves of great judges, who have continued to render eminent public services through a long term of age. The Insurance Offices, until recently at least, gave more distinct results as to the value of clerical life in England. The Clergy, in truth, have formed their highest description of insurances; affording an average of life considerably beyond that of any other class. We have great reason, however, to doubt whether the hard-worked clergyman of the present day will maintain this average for the future. The Medical profession, both in England and elsewhere, comes much lower in the scale of longevity. No material for satire can be drawn from this fact. The hard labours, broken rest, and anxious responsibilities of medical men, and their much greater exposure to infection and other causes of disease, well explain that, while seeking to prolong the lives of others, they are often shortening their own.

The longevity of statesmen, and of men of letters, forms another curious topic of enquiry; but of greater difficulty from the more doubtful definition of these classes. Here again we must reject the evidence of particular cases, as not leading to any certain conclusion. We read of Henry Dandolo reaching the age of 97; Cardinal Fleury, 90; Bolingbroke, 79; Alberoni, 80; Pombal, 83 years. In our own times we are familiar with the venerable aspect and antique manners of Talleyrand, Metternich, and Nesselrode — statesmen who have played so various a part amid the changes of dynasties and the conflicts of empires. And again, among the greatest men of our own country, less exposed indeed to revolutionary storms, we find the names of many who, happily for this nation, have continued the eminent labours and services of earlier life into a prolonged age of honour and usefulness. Of the Duke of Wellington

it was well said on the morrow of his death, that he had exhausted nature as he had exhausted glory. And to the same generation belong the names of Lansdowne, Lyndhurst, and Brougham,— still maintaining, under weight of years, the native vigour of mind, eloquence, and ability which have marked every stage of their career. But, after all, such cases interpret only individualities of temperament, and afford no answer to the general question. The same is true in the case of literary and scientific men. We might quote the instances of Hobbes, Voltaire, Fontenelle, Heyne, Goethe, Newton, Kepler, Halley, Cassini, Maria-Agnesi, Humboldt, and others, all reaching ages between 80 and 100; but we can venture no general affirmation grounded upon a few examples of this kind.

From these topics we pass to another of close affinity with them, viz. the influence of those passions, cares, and excesses of mind which belong to the strange and fitful history of human life; and affect every part of it, from very infancy to the extremity of age. It would not be easy to estimate the relative influence of moral and purely physical causes upon longevity. They are so mutually consequent upon one another, so interwoven in all ways, that reason is perpetually at fault in seeking to distinguish their effects. What we have hitherto been discussing are chiefly facts, measured more or less exactly by numbers and tables. The topic to which we now allude cannot be reduced under any formularies, and is indeed not easily rescued from those commonplace maxims which have currency in the world. That the passions and anxieties of life, if protracted or in excess, do more or less tend to shorten its duration, either by chronic impairment of health or by sudden injury to some vital organ, is a truth too well known to require argument. And deep though the interest of the subject is, we can give only a passing notice to it.

The simple but certain fact is what we have already stated, viz. that the healthiness of the organs ministering to the several functions of life constitutes the health of the man; and in the same proportion tends to prolong his age. Though physiologists hold some verbal dispute on this point, yet can we hardly define Vitality otherwise than as a force or power, acting through the intervention of the nervous system upon organic structures, and depending upon the integrity of all these parts for its own amount and completeness. While admitting that the power is one which controls, and often seemingly contradicts, the physical laws most familiar to us, still we see that it is a power generated within the body; that matter and organisation are necessary to its action; and that by these it is variously and unceasingly altered through every part of individual existence. We are enabled, and indeed almost compelled, to speak of it as a *quantity*; — varying in different individuals by original organisation; — in each fluctuating continually during life; — and reduced to its minimum where life is prolonged into old age. What poetry has described as the blood in 'languid eddies loitering into phlegm,' may not be physiologically true; yet it is in some sort sanctioned by the doctrine of a great physiologist as to the especial vitality of this wonderful fluid; of which, even now, we do but partially know the physical properties and the changes it undergoes in health and in disease.

Carrying this view into the practical question how vitality may best be maintained and prolonged into old age, we must look mainly to *four general conditions*, which may be said to include all that is most essential to the fulfillment of the object. These are, air, as belonging to the function of respiration; — aliment; — exercise of the body; — and exercise of the mental functions.

The first of these topics — that of the air we breathe — presents more difficulties than might be supposed; owing in

no small part to the vague notions and prejudices current on the subject, and which science has hitherto but partially corrected. The contingencies of climate, for instance — whether hot or cold, wet or dry, equable or variable — are made the subject of current phrases, often unfounded in fact, and as often of injurious application. Since the Continent of Europe has been laid open to universal travel, local interests and fashions have tended further to distort the truth; and health is run after, whether from climate or mineral waters, upon the most ignorant plausibilities; and with little regard to other circumstances which often more than contravene the benefit sought for. The lungs may gain good from a warm atmosphere, but this may be paid for by gastric disorders scarcely less noxious. Heat is too commonly regarded as a panacea for all our bodily ills. In truth, cold has an equally fair title to take its place in the class of remedies; for in many cases where health is inertly loitered away under southern suns, the frame might have gained vigour and vitality among northern mountains. A comparison of the registers of mean mortality in these respective localities goes far to sanction this opinion.

But we must not deal with this subject as represented by climate only. The amount and purity of the air we breathe is a question belonging to every place, and of far more interest to the great mass of mankind. We do not here enter into the chemical theory of respiration, or the several controversies it has engendered. What concerns us is the fact, that a certain number of cubic inches of air taken into the lungs at each inspiration, and this air of a certain purity, are conditions necessary to the health and full vitality of the individual being. The imperfect attainment of these conditions throughout the whole, or a part of life, tends in the same proportion to enfeeble the vital power, and to abridge more or less the term of existence. The insufficient

production and maintenance of this power impairs longevity, not less than its too lavish expenditure in the various abuses and vices of social life.

Hence the vast importance of all that may be done by open air, exercise, ventilation of dwellings, and removal of noxious exhalations, on behalf of this great function of life. These things are better understood than they were, and more is attempted and effected for their attainment. Medical science is now called upon to prevent disease, as well as to restore health. Much more might be accomplished in this way, as well for individuals as for communities, were the healthy state of respiration cultivated with the same care which is given to the actions of the stomach and alimentary organs. We doubt not, for instance, that this function is capable of being restored, improved, and maintained in efficiency, by well-ordered exercises of the lungs; and by due attention to the mechanism of these organs in all that belongs to the habits of life. It may not occur to our readers, and yet it is strictly true, that the familiar conditions of posture of body, speaking, singing, &c., are deeply concerned in this matter; the more so from the very familiarity of every-day use. If forty cubic inches of air taken into the lungs at each inspiration are required for the purposes of their function, and thirty or twenty only are inspired, it is certain that the blood will not be duly changed, and that every organ and action of the body will suffer more or less by this deficiency. To enlarge the quantity then in such cases is an object of high importance; not sufficiently regarded, we may add, in the medical practice of our day.

Of the value to health of the purity of the air we breathe, it is hardly necessary to speak. Free ventilation is here the main agent in our hands, whether we look to the replacement of air despoiled of its oxygen, or to the removal of noxious matters present in it. Our actual knowledge, it must be

admitted, does not enable us to exclude altogether those noxious ingredients (some of them doubtless animal or vegetable organisms) which produce epidemic and endemic diseases. Nor can we yet deal with those equally unknown influences on the body, for good or for ill, which depend on electrical states of atmosphere, the proportion of ozone, &c. But science is now actively directed to these various objects; and meanwhile we may fairly assume change and freedom of air by ventilation to be the most efficient preventive means in our power.

Looking next to aliment in its connection with health, and therefore with longevity, we encounter a topic which has been endlessly discussed and written upon, and made the subject of various and conflicting opinions. All this is natural and inevitable. For the subject in question embraces not only what is necessary to human existence, but also what belongs to man's luxury and sensuality; and is, moreover, connected with all those changes of bodily condition, whether healthy or morbid in kind, which are most open to common observation. Including further those many forms of liquid, from simple water to the strongest alcoholic drinks, which the natural or perverted ingenuity of man has mingled with his aliment, it brings in another class of effects, of deep interest not only to individuals but to the welfare of social life.

Vague though it may seem, we can find no more fitting word than *moderation*, to express that which is best in diet in relation to health and length of life. No specification of the wholesome or unwholesome in food can be of avail for good, unless submitted to this one condition. As in the relation of the lungs to air, so the digestive organs require a certain quantity of food — varying in different individuals, and in the same person, at different periods — to maintain the healthy state and sufficiency of the blood, and through this

the due action of the nervous system, and of all the organs of the body. And nature, where unspoiled by vitiated habits, furnishes a rule and measure which everyone, whatever the diversity of temperament, may safely and expediently consult for himself. Here especially, however, men are more prone to be governed by faulty habits and injurious maxims, than to be convinced by reason or instructed by experience. That appetite, for which the old epicure would pay any price, is too much regarded as a condition to be instantly removed by food. Even under disease, when nature resumes her rights, and rejects with loathing the aliment the stomach has no power to digest, the mischievous zeal of friends comes in; feeding the disorder and not the body, by what they force upon the patient. The catalogue of ills which indigestion directly or indirectly involves — from the early oppression after food, to those later and more various effects, both on body and mind, for which the *hesterna vitia* are responsible, — might seem sufficient to enforce a rule, were they duly recognised in their origin. We may reasonably regret that the term *dyspepsia*, while actually expressing this origin, should in effect throw a sort of classic veil over the simple and certain source whence these ills arise. Common phrases are better suited to common things, and more salutary in their influence.

It has been a question mooted of old and often revived, whether intemperance in food, or in drinks, is most injurious to health and life. An eminent physician of antiquity, Celsus, pronounces against the former; and if the question be so put as to exclude the wilder forms of inebriety, we may perhaps acquiesce in this opinion. There is some risk, however, in discussing a matter of preference, where both contingencies are so prolific of evil. It is not uncommon to hear instances cited of prolonged life in drunkards, and doubtless such do occur. But they are as certainly ex-

ceptional; and fairly subject in each case to the common and obvious explanation, that life would have been longer extended had the habit been otherwise. The drunkard who dies at 70, might have reached 80, if sober.

But while thus associating moderation of life with length of life, we are bound to add that there may be excess even in this laudable direction. A constant and anxious care for existence, and rigid rules of living founded upon this, tend in their own way to curtail what it is sought to prolong. There is some practical truth in the story in the Spectator, of the gentleman who cut short his life by weighing or measuring every article of his food. Of the famous case of Cornaro we have already spoken, as not justifying all that M. Flourens seeks to derive from it. The truth we consider to be — and it is a physiological fact — that whatever leads the mind to give close and minute attention to the stomach and organs of digestion, does more or less embarrass that great function, and impair the nutrition of the body. Temperance must not be made to march in manacles and fetters, or with steps of unbroken uniformity. We degrade the virtue by this manner of using it; and attempt what is impossible under the endless changes incident to the life of man.

It remains for us to speak of exercises of the body, in their reference to longevity. Under the definition of vitality already given, it will be obvious that whatever tends to maintain the organs generally in their healthy state, tends in the same proportion to preserve and prolong life. Exercise is one of the great means to this end. An organ destined to a particular function is best kept in its integrity by the exercise of this function, with a due regard to those progressive and inevitable changes which time brings upon every man. If we take the term exercise in its ordinary sense, as expressing the muscular actions of the body, the conclusion is the same; — rendered still more explicit by our knowledge of the

influence of these actions in maintaining the vigour and equality of the circulation throughout the system, and very especially in the skin and extremities; thereby keeping all the organs in healthy balance and relation to each other. Many organs — systems of organs they may even be called — make up the wonderful fabric of our physical being; the due balance among which (disturbed more or less in every form of disease) is at once the cause and the expression of bodily health. The changes fitting or necessary in the habits of exercise, as old age comes on, cannot be measured by years only. The time and the necessity vary for every individual; and must be determined for each by a just observation of himself. A wise man will find steps and stages in the descent of life on which to repose a while; without sudden or entire relinquishment of those bodily habits which, discreetly used, conduce to health and preservation at this period as well as in youth and middle age. The discretion needful is that suggested by experience. Whatever amount of exertion is sensibly felt to exhaust the bodily powers, in any of their functions, is fitly to be avoided. Whatever can be maintained without such effect is certainly safe and probably beneficial.

A story is current of Lord Mansfield, who himself lived to 89, that whenever very aged witnesses appeared in the Court over which he so long presided, it was his wont to interrogate them as to their habits of life; and with the result that in no one habit was there any general concurrence, except that of *early rising*. Such anecdotes are for the most part either untrue or exaggerated. Early rising is doubtless in many ways favourable to health; but it cannot be taken as a guarantee for longevity. Even were the story in question true, it is more probable that the vigorous vitality in these instances maintained the habit, than that the habit alone maintained the vitality.

What has just been said about exercises of the body in relation to longevity will, in great measure, apply to the mental functions also. We cannot indeed assume, because facts disprove it, that there is any exact parity between the mind and body in their connection with mere age. The mind may, and often does, retain its faculties little impaired, when vitality, as expressed by the bodily powers, is reduced to the lowest ebb. But let this reduction go further and they too give way; in obedience to the common law which the Creator has assigned to man on earth. The question before us regards the capacity for prolonging their duration, and the means conducive to this end. And here we come upon the track of a great writer, whose views on the moral and intellectual culture of old age, though somewhat florid in colouring, have always earned the respect due to his name and philosophy. The doctrine of Cicero is that the faculties of the mind in old age are best maintained by their exercise. '*Manent ingenia senibus, modo permaneant studium et industria.*' In this doctrine, and on the same grounds just asserted as to the preservation of the bodily powers, we may fairly acquiesce. Every intellectual faculty is dulled and diminished by want of use. Each one is maintained in vigour, if not improved, by its fitting and temperate employment. This maxim, true generally to every time of life, requires no other modification for old age than the simple one of additional care that there be no habitual excess. Vitality is weakened or exhausted by intemperance of mind as well as of body; and in old age is less easily repaired. The brain, that organ which comes in such close and mysterious relation to the mental functions, more especially needs this forbearance in advanced life. At this period it readily becomes the subject of disordered action or disease from any excess of use, even of the intellectual powers; — much more still from any intemperance or disorder of the moral

emotions. Quietude and forbearance form the right rule in our hands, and not premature disuse and abandonment of the faculties committed to us. These beyond doubt are better preserved by their exercise, within the limits we have just denoted.

Here again we have the authority of Cicero to refer to, and willingly adopt it. He gives us various instances of the exercise and preservation of the mental faculties to an extreme age; and such examples, in truth, are familiar at every period, and to the individual knowledge of us all. We might cite many that have come within our own experience. For the most part, it must be admitted, such cases as these are connected with a sound bodily organisation, concurrently preserved. But this, as we have already stated, is by no means uniformly the case. The disproportion of the two powers makes itself known to us in numberless instances. From the

> Souls that can scarce ferment their mass of clay,

to that elsewhere described by the same great poet: —

> A fiery soul that working out its way,
> Fretted the pigmy body to decay,
> And o'er informed the tenement of clay, —

we have every grade of relation between the two great faculties, which in their mysterious conjunction make up the nature of man. No more curious, but no more difficult part of human physiology than that of defining these relations, and the conditions which influence and alter them. Here it is that disease often serves us as the best interpreter; by detaching and insulating, as it were, different functions, which in health are so closely associated as to escape all division or definition.

The Memory is generally the mental faculty which is first

and most obviously affected by old age. This wonderful intermedium between body and mind, varying so greatly in different individuals, and so strangely capricious in the same individual from the accidents of the day or hour, would seem to partake more of mere mechanism than any other of the intellectual powers. It undergoes changes more explicitly from physical causes; and both its excellences and defects are marked by peculiarities which appear to belong to conditions of organic kind. The anomalies of memory in advanced life are familiar to every one; especially so the fact of the early forgetfulness of names, and the frequent retention of things long past, while recent events flit away like shadows, leaving scarcely a trace behind. Or, more strangely still (though never perhaps without some morbid changes of brain), the obliteration of certain classes of events or certain subjects of memory, as if by a sort of mechanical separation from everything else abiding in this mysterious receptacle.

The importance of preserving memory in its integrity, as long and as far as it can be done, will probably be admitted. Some may urge that an oblivion of things past is the best security for a tranquil old age. But this virtually reduces man to a mere fraction of existence; and the same reasoning might be used to prove that utter imbecility of mind is a blessing in this latter stage of life. Such imbecility, from natural causes, often occurs; but we have no title to consider it a good, or to neglect any means which may obviate or retard it. We will not venture to say that these means are many or certain. As regards memory in particular, all that can be done at this period of life is to aid in giving it the direction which circumstances make desirable, and to spare it those painful efforts at recollection which seem to weaken the very faculty they exercise. The latter remark we believe to be of valuable application to other periods,

long antecedent to old age; but especially perhaps to that time when the faculty is first felt to decline in clearness and power. Recollection (that is, the effort of the mind to combine or extricate what is laid up in the memory, the *ἀνά-μνησις* of Aristotle) cannot be carried beyond a given point without begetting a certain confusion of mind, hurtful to the faculty itself, and probably to others also. The consciousness of everyone will give proof of this; and at the same time, if truly consulted, warning to avoid it.

We cannot close this article without adverting to that question, which at every period has been so variously agitated,— whether longevity be desirable, or not? A momentous enquiry indeed, if it really admitted of any determinate answer. But none such can be given. The conditions are far too complex to warrant any general conclusion; and even in individual cases, and with direct appeal to those concerned in the question, the difficulties are hardly overcome. The feelings of one moment change at the next. Even where their expression may be relied upon, longevity itself is a vague term; and rendered more so by the various contingencies of health and power preserved, which alone can give just measure of life or of the capacity to enjoy it. The old man of 80, and he of 100, may be on a par as to those conditions upon which we found our only valid estimate for each.

We must then receive with some allowance those writings, eloquent though they may be, in which the cause of old age, as such, is pleaded before us. Here the name and authority of Cicero again come into view. Though we are unable, with Montaigne, to say of his treatise 'De Senectute,' '*il donne l'appétit de vieillir*,' we can well admire the fervour with which he maintains his thesis, and the happy ingenuity of his argument. Nor can we grudge him his eloquent

abstraction of what old age *might* be; while admitting that, however rare and difficult their attainment, the objects and methods he indicates are all fitted to give honour, tranquillity, and usefulness to this stage of life. Add to these the religious confidence, which Cicero could only vaguely, if at all, proffer, and we have a summary of whatever is in man's power towards the attainment of that worthy object, a happy and venerated old age.

But, to reach this end, the preparation must be begun long before. Without infringing too far on the style of the pulpit, we may point out the main fact that the habits, feelings, and interests of earlier life are all carried forward into old age; and often intensified in degree, by the removal of the circumstances which before tempered or constrained them. '*On ne jette point l'ancre dans le fleuve de la vie,*' is the happy phrase of an old French writer for that continuity of life, by which all its parts are linked together; and the young man, in his intellectual, moral, and physical habits, becomes the interpreter, more or less, of what follows in his after-age. When Lord Bacon says, with his wonted weight of words, 'Strength of nature in youth passeth over many excesses, which are owing a man till he is old,' he expresses a physical as well as a moral fact, which cannot be too well weighed in the education and conduct of early life. It is a maxim full of practical wisdom.

We have already alluded to the various sentiments with which old age, and approaching end, are regarded by the aged themselves. In many of them the desire to pass away, and this even without the solicitation of active pain or suffering, is equally earnest and sincere. It is with them as with the 'Tre vecchi' in the Purgatorio of Dante:—

E par lor tardi
Che Dio in miglior vita li ripogna.

Individual temperament is partly concerned in producing this weariness of protracted life; but other causes also come into operation to which we have not space to advert. There is one fact, however, which we may briefly notice, inasmuch as it seems a providential dispensation to the latter stages of existence; and we do so by borrowing a few lines, which succinctly express the circumstance to which we allude.

No previous reason or feeling, no judgment of vigorous health, can afford a right estimate of the relation the mind assumes to death in the latter hours of life, even where little impairment of its faculties has occurred. This is especially true where long and painful sickness has been the prelude to the event. But the exhaustion even from acute pain of short continuance alters this relation; and even without sickness or suffering of any kind, the mere diminution of vital power by general decay produces the same effect. The earnestness to live abates, as the possession of life, from whatever cause, is gradually withdrawn.*

This, we think, will be recognised as true by those who have been observant of these things; and witnessed the changes which gradually supervene on the feelings, as the physical conditions of vitality abate in power, and action subsides into repose. We willingly close our observations at this point. If unable to assent to the doctrine of M. Flourens that a century is the natural term of human longevity, we thoroughly agree with him that individual habits may be made to contribute much to the healthy prolongation of life; and we can affirm with assurance that these habits are such as best accord with the happiness, dignity, and higher destinies of our species.

* Medical Notes and Reflections, '*On the Medical Treatment of Old Age.*'

ROMAN HISTORY — JULIUS CÆSAR.*

[Quarterly Review, March, 1851.]

STRANGE though the fact may seem, at a time when learned and ingenious men are seeking subjects throughout every domain of human knowledge, it is certain that we have no English work, deserving the name of a history of the Roman Empire, prior to the point at which Gibbon takes up his vast and splendid theme. Nay, this deficiency, it can hardly be denied, extends over much of the antecedent period. It might fairly be deemed a vacant field to which Dr. Arnold came, when he undertook the work which was abruptly and unhappily terminated by his death. His learning and candour fitted him well for the task; and though there are some defects of method in its earlier part, no writer need disdain the task of completing what he has thus begun. Such completion is imperatively required to sustain the fair fame of our literature; so faulty on this subject, that even now it is difficult to place before the student any English book which creditably relates the great events intervening between the close of the second Carthaginian war and the death of Sylla.† The work of Middleton

* *A History of the Romans under the Empire.* By Charles Merivale, B.D., late Fellow of St. John's College, Cambridge. 2 vols. 8vo. 1850.

Feb. 1862. The seventh and concluding volume of Mr. Merivale's History is now, we believe, on the point of publication. The work thus completed, forms a most important and valuable addition to English historical literature.

† The valuable History of Rome by the present Dean of Christchurch had not been published when this article was written.

comes in at this time; but owes its reputation much less to its own merits or originality than to our deep interest in the actions it records, and to a comparison with the bald and feeble essays which precede it; — volumes uninformed by critical research, and destitute of every charm which style or philosophy can afford.

Our continental neighbours have dealt more copiously and successfully with this great subject. In France the writings of De Beaufort opened that vein of sceptical enquiry as to the early history of Rome, which has since been so boldly pursued elsewhere. To the theme of her grandeur and decay Montesquieu brought his high philosophy; Vertot, Michelet, Thierry, &c., have furnished works well fitted for study; while other writers have diligently pursued those researches which connect the Roman Empire in Western Europe with institutions and usages existing down to our own times.

The German scholars of the last half century have given to the Roman History that zealous and minute labour which is their great characteristic. It may well be called an exhaustive power of research, for they leave no record or fact untouched; though often, it must be owned, without a sufficient regard to the authority or worth of the materials they accumulate. They have taken up this subject, like others, not merely on the broad scale of history, but in detached parts; illustrating more fully the course and effect of certain political changes, and the career of those men whose genius or fortune have urged on such revolutions. We may notice as examples Schulze's history of the Republic to the time of the first plebeian consul; Hegewisch's and Heeren's history of the Gracchi; Heyne on the social war; Schleuter's history of the period between the two narratives of Sallust; Meissner's life of Julius Cæsar. The more recent work of Drumann well deserves the euolgiums Mr. Merivale has bestowed upon it, and the use he has made of it in his

own. Nor can we omit mentioning the *Stemmata Gentium Romanorum* (the genealogy of Roman families) of Ruperti, as one of the most valuable aids to Roman history yet published. Finally, we must name the great work of Niebuhr; coldly or harshly critical it may be; often theoretical; and in parts doubtful or mistaken; yet correcting much of common error, and affording a juster estimate of the relative value of those documents, whether Greek or Latin, from which the Roman history is derived.*

Mr. Merivale now aspires to fill the historical void in our own literature. We opened his book with interest, but not without jealousy; because, even if it had not worthily fulfilled the objects designed, it might yet have so far succeeded as to deter others of higher pretension and literary power from attempting the same labour. This is a space in the world's history far too vast and important to be allotted to anyone who is unable to found thereon a fair and lasting edifice. Mr. Merivale, however, was already known as a very accomplished scholar; his reading and power of Latin versification had been placed advantageously before the public; while his 'Age of Augustus,' published a few years ago, was a natural antecedent, and to his readers a full justification of the present undertaking. Whether he regarded it as tentative of this larger work, or was led to the latter by getting thus far into the subject, he does not inform us. But we can well understand that a writer who found himself immersed in the epoch of final change from republic to monarchy, might naturally proceed to spread his scheme over the first great period of the Empire.

Mr. Merivale could not have dispensed with a preliminary

* Since this article was written, the volumes of Sir George Lewis, on the 'Credibility of Early Roman History,' have shown what may be done by an accomplished scholar, of equal industry and learning, even amidst the labours of high official life.

outline of Roman history, even from its origin. In any case, to render such a summary clear, just, and effective for its purpose, is the highest test to which an historian can be put. In the case of Rome, the difficulty exceeds perhaps that of any other. We think ourselves familiar with its history from the teaching of schools; though this knowledge is usually but of events only. Few comprehend at all distinctly the strangely interwoven elements of Roman government and internal polity; the progressive changes therein; the mutual effects of these changes; the influence of foreign conquest on the social and political condition of the State; or those other more secret and subtle causes which are ever at work, altering or undermining all human institutions. If the reader has at any period devoted himself to such studies, the summary in the first of these chapters may be sufficient to refresh his memory of all that is most essential. But we have some doubts whether it will adequately instruct those who come only half informed to the subject, and for whom it is the duty as well as profit of the historian to smoothen the road to the threshold of his work.

Mr. Merivale opens his volume with a somewhat ambitious description of the topography of the Seven Hills; and depictures the isolation and fierceness of the Roman character, as connected with the solitary wildness of this locality. 'Such a position,' he says, 'was admirably adapted for a place of retreat, and offered an impregnable shelter to crime and rapine. It seemed created by Nature herself to be the stronghold of a people of reserved character and predatory habits. It was destined to become the den of the wolves of Italy.' Our author is hardly justified in thus describing the early Romans by the phrase of a defeated enemy. Nor have we much faith in the inferences here drawn. The Seven Hills, even if they offered shelter to the infant city, did not nurture it into greatness. They owe everything to Rome —

not Rome to them. A hundred localities of the same land would have offered like advantages. The soul of Roman greatness was not in the shelter of its hills, but in its civil and military institutions, and in the unity of spirit and vigour of action they engendered; which kept the State from being ever confederate with others, save when she became their conqueror and chief.

The growth of a single town, small and obscure in its origin, into the empire of the then known world, is a prodigious phenomenon. We need thus to bring together the two extremes, before we can fully comprehend how greatly the fact surpasses any kindred event in the history of nations. And even in the decline and fall of this vast fabric of power we have fresh cause for wonder at the slender foundation of an edifice, stable enough to resist so many centuries of decay, and leaving such ample vestiges to later ages. Fortuitous causes are out of the question; nor is any theory of race or temperament more admissible. Whether we consider the founders as a colony, or as a band of lawless adventurers, which Mr. Merivale seems to suppose, equally certain is it that they were of the same Latin stock as other neighbouring tribes; — modified, it may be, by intermixture, or other incidents to which such small communities are liable. Throwing aside what is poetic and legendary in the history of Rome, we cannot look elsewhere than to moral causes for its grandeur of growth. Partially modelled under the rule of the kings; — more largely evolved in the change to republican government; — farther extended and matured by those internal struggles of classes which more than once threatened the existence of the State — the institutions of Rome survived in show when their virtue was extinct, and lent a specious shelter even to those usurpations which converted a republic into an empire. The outward forms of the Roman Senate were continued as matter of policy,

long after their real grandeur and political efficiency had passed away.

The living energy these institutions possessed in the better times of the Republic has no parallel in history, ancient or modern. The harsh and limited character of Spartan institutions removes them from the comparison. Athens, even in the utmost vigour of that democracy which so deeply engages Mr. Grote's admiration, did not put forth the unity of action, or create that passionate devotion of citizens to their country, which is so striking in the annals of Rome. The internal polity of Venice was too complex and corrupt, even in its best days, to admit of its being brought into the parallel. With every allowance for that various casualty of events, to which nations as well as men are liable, it is impossible not to see in the fate and fortunes of Rome how much her constitution rose above others in solidity and active power. The successive and fierce struggles of the plebeians for a guarantee of personal liberty, for division of lands, and for equal right to all the offices and rewards of the commonwealth, show how deep the foundation was laid; these contests actually invigorating the State which at the moment they seemed fated to ruin. The expression of Florus, *Magna populi Romani fortuna, sed semper in malis major resurrexit*, applies as well to the recovery from civil dissensions as to her proud survival of the foreign assaults which repeatedly menaced her existence.

Though the greatness of Rome could not have arisen from fortuitous causes, yet we must admit that the adoption and growth of the institutions which engendered it may have resulted much more from what we call accident than from actual design. In truth, no human intention could have produced such a fabric, any more than it could have created the complex structure of our English constitution. We have every reason to suppose that Rome adopted into her primi-

tive government many usages from the Latin and Etruscan states. These were progressively moulded and modified as with us; — in some cases by convenience or necessity, in others by the direct collision of different influences and classes. In both instances the result may in part be attributed to the comparative insulation from neighbouring states. While the Etruscan and Latin cities were engaged in confederacies, more or less extensive and binding, Rome was almost always single in her course of action. Her connections with other states were mainly those of conquest and supremacy. Her institutions, whether of peace or war, all appertained to the City itself. Her rights of citizenship, even when most extended by prudence or necessity, flowed from within to without. Her colonies, unlike those of the Greeks, never assumed the condition of independence. Her most distant wars were conducted, her most distant provinces ruled, by men chosen within the walls. The forms and superstitions of the national religion were maintained wherever her arms or her magistracy were present. Conditions like these, however originating, could not exist without large influence on the destinies of a state. Yet the greatness thereby created had in it a germ of decay, derived from those very elements of power, and growing with their operation.

In one of Hume's essays he mentions three anomalies of government as among the most singular which history affords — the *γραφη παρανομων* of Athens, the relation of the Comitia Centuriata and Comitia Tributa of Rome, and the impressment of seamen in England. The second of these is, indeed, a striking instance of the peculiarity and integrity of Roman institutions. Here were two distinct legislative bodies; opposed to each other in origin, interests, and manner of action; yet, amidst all the civil contests in Rome, the only instance of actual collision between them is one recorded by Appian, trivial in itself, and happening at a time

when the Republic was well nigh extinct. No one beforehand could have predicted such a result. No state has afforded a similar example.

The office of Dictator, in itself almost as great an anomaly, must be counted among the most admirable of the Roman institutions. Based on the principle of preservation of the commonwealth, it rested for its action on public virtue and obedience to law; and it is wonderful for how long a period, whenever the agency was invoked, this confidence was justified by the result. Some partial analogies to the office might be found elsewhere; but none approaching it in grandeur and efficacy. It is purely Roman in its every part; — in the choice of men; — in the limitation as to time; — in the frequent surrender of the dignity the moment its object was fulfilled; — and even in the law, trivial as it may seem, which forbade the supreme functionary to appear on horseback without permission of the people. A void of more than a century had occurred in the Dictatorship when Sylla assumed it. But it was the name only, without the ancient virtue of the office. The Dictator was now the military tyrant of the State, no longer the guardian of its safety and freedom. The fact is one which well illustrates the mighty change that had already taken place in the social and political condition of Rome.

The author who is about to record the change and decay of the Roman constitution ought clearly to expound this constitution in its nascent and progressive state. Mr. Merivale has given a rapid but faithful summary of the struggles on the agrarian laws; — of the momentous changes which raised the *plebs* to equality of privilege with the *populus*; — of the principle of Roman colonisation; — and of the contests and concessions by which the citizenship of Rome was finally extended to all the Italian states. But he says too little respecting the origin of the Roman people, or of those forms

of government which conduced to their greatness; — and alludes to the peculiar isolation of the Republic rather as a proof of their barbarous character than, as we have found cause to consider it, an element and cause of their progress and persistent success. He speaks of them indeed as the *normal type* of a conquering race; but very slightly shows whence this type arose, or in what it consisted.

He has justly and vividly depicted the increasing and already intolerable corruption of Rome at the time when his narrative opens. Many causes contributed to this; — none more than the system of provincial rule. Consulships, and other curule offices were sought for, not from regard to the public weal, but as steps to the government of those provinces which yielded most ample spoil. No sovereignty so harsh or destructive as that of a Roman proconsul, fostering his private vices, or forwarding the projects of his future ambition, by the riches torn from his temporary subjects. The recorded wealth of Crassus was less nefariously acquired; but the high position it gave in the commonwealth to a man of his slender merit, strikingly illustrates the change of manners that had taken place. The growth of the City, increasing with that of dominion and citizenship, brought together a base and brute multitude, alien to the glories of Rome, and ignorant of the better institutions of the ancient time; — ready indeed to render service to any Catiline or Clodius who might call them to the work of revolution and plunder. These abuses had sunk so deeply into the morals and discipline of the Republic, that the restoration of primitive ideas and usages became impossible. It would have taken a whole generation of Catos to accomplish it; and of Catos more truly wise and practical than he who has carried the name to posterity. The institutions and virtues of Rome had alike decayed; and that decay was not the simple decrepitude of age, but the worser disease of human passions let loose by prosperity and

power. Both within the City and without, save among a few old republican enthusiasts, there existed the feeling that a change was at hand — inevitable if not desirable.

The epoch of Marius and Sylla, and the civil war begotten by their ambition and jealousy, form a threshold to the events which occupy the still more remarkable period before us. These extraordinary men, each victorious over foreign enemies, each taking the badge of a party and contending fiercely for superiority at home, did much to hasten the catastrophe in progress. Marius — an admirable soldier, but coldly and brutally unprincipled — is readily understood. He assumed the cause of the Italian states against the ruling aristocracy of Rome, from the personal motives just named, and to recruit the armies which subserved to these objects. He probably had no real purpose beyond, though party spirit gave him credit for such. Sylla was of higher stamp; — one of those who stand out in bold relief on the world's history; great in intellect, constant in purpose, intrepid and powerful in action; but blasted in his moral part by a contemptuous indifference to human life, virtue, and happiness, which led to the perpetration or permission of cruelties, hateful in their very record. It needs a large view of the contradictions of human character to explain the anomalies of this man's mind and career. It is usual to speak of him as the champion of the nobility and old senatorial families against the encroachments of democracy within the City, and the pressure of the new citizenship created without: and such undoubtedly he was in the changes he effected during the two years of his dictatorship. But we stop short of believing, as some do, that his single and settled purpose was that of restoring the integrity of the Republic. Personal passions mingled themselves with, if they did not decide, his public acts. An early hatred of his rugged rival Marius was embittered by time, and by the cruelties of their protracted con-

flict. Ambition had doubtless also a large share in moulding the events of his life. Such a man, so gifted with the ability for power, could not do otherwise than grasp at it. His sudden abdication of what had been won at such cost of toil and blood, is not so incompatible with this as it might seem. We dare not set down anything to principle; but neither can we admit the notion of fear as prompting the act. We look rather to the pride of a man who had nothing further to gain; to his contempt of the world he had thus mastered, and to his love of luxurious indulgence, as it is described to us by the writers of the age. Or it might be, that he already felt the approaches of the disease, whatever this was, which shortly after ended his days. The annalist easily records that event which stops alike the career of all — of the great, the brave, and the wise — but he is ignorant, or takes little note, of those more subtle causes, which though not sufficient to stop the current of life, yet check and turn it aside in its course; — of those physical changes which put passions to sleep, and paralyse the powers of action. History revels in tales of poison and secret assassination, but is silent as to the secret disease of organs — the slow poison of bodily decay. Yet it is certain that these things are deeply concerned in worldly affairs; and we could suggest many cases of historical paradox, which may be best solved by looking to them alone. Such documents, however, are written for the most part in too delicate a character to be legible by the historian; and we must needs be content with, and give what credit we may, to the coarser materials which are put in evidence before us.*

Again, there is an obvious facility in defining character by strong and arbitrary lines; and there may often be a moral

* Since this article was first published, two biographies of Sylla have appeared in Germany, by Drs. Zacharia and Lau, manifesting the usual industry of German research.

use in this, inasmuch as the highest grades of virtue and excellence are those which best will bear such definition. But the author who generalises too much in this matter invents a drama rather than writes a history; and his personages become puppets, moved by his own hands, not the real actors on the great stage of the world. Though it be true that every man has a certain mental and moral temperament from his birth, more or less apparent throughout life, yet is human character, in the common sense of the term, made up of too many elements often strangely incongruous in themselves, to be submitted to any standard of unity. Accidents and conversions interpose in this as in all other human things; and it would be hardly less an error to attribute all events to a blind fate than to assign them universally to fixities of purpose in the agents. The consciousness of every man tells him of such alternations and anomalies in himself. The appeal from Philip drunk to Philip sober has a meaning beyond the mere anecdote; and the noble poetry of Dryden is true to life in picturing, under another influence, the rapid changes of mood and mind in Philip's greater son. We advert to this matter, not as a mere contingency of error, but as an actual fault in historians; — a fault which it is the more needful to guard against at a time when fiction, open or concealed, presses so hard in various ways on the true history of mankind.

Scarcely had the troubled period of Marius and Sylla come to a close, when there sprang up the concurrence of four wars; — that with Mithridates in the East; the vigorous struggle of Spain under Sertorius in the West; the devastating war of the pirates in the Mediterranean; and that of the gladiators in the very centre of Roman power; — contests formidable separately; — capable perhaps of subverting the Republic, could they have coalesced in action as they coincided in time. These wars, whatever their effect on the fortunes of

Rome, gave lustre to the name of one great commander, and raised him to high influence in the State, strengthened by his relation to the ruling aristocracy of the City. The yet greater rival of Cneius Pompeius had no such early harvest of glory. Though his descent was ancient and distinguished, and his talents always conspicuous, yet was he chiefly known during the first period of his life in city profligacy or party conflicts; and gave little certain augury of that wonderful career of victory which made him master of the Roman world, and rendered even his assassination ineffectual to annul the sovereignty he had created.

Our author's second and third chapters are chiefly occupied with the conspiracy of Catiline, and with sketches of the character and early life of the two illustrious rivals just noticed, and of others who played an eminent part in the great drama of Roman revolution now approaching to its crisis. Of what relates to Julius Cæsar we shall have occasion to speak afterwards. As respects Pompeius — (or we may be pardoned for adhering to *Pompey* as the name naturalised with us) the estimate Mr. Merivale forms of his character and public conduct is probably just on the whole; though we think he commits the error of defining too absolutely the course of thought and policy which led to his public career. It may be that Pompey saw and felt what our author affirms he did; but there are several circumstances which inspire great doubt on the subject. Energetic and successful in military action, his political course, where not actually feeble, was tortuous and uncertain even to his friends and confederates. Adopted the successor to Sylla as leader of the aristocratic party, he was often lukewarm, sometimes a traitor to their interests. His accession to the triumvirate comes closely under the latter interpretation. His permission of the violent and flagitious acts of Clodius when he might have prevented them, can hardly be explained, still less vindicated; and his

relations, political and personal, to Cicero aggravate this charge against him. Warm and amiable generally in his private affections, he wanted the vigorous consistency needful to his ambition — more urgently needful when engaged in competition with a Cæsar. He brought to this conflict for the mastery of Rome the fame of his former acts and the support of the old nobility; for whom, though with a confidence abated by time, he was the only hope. Cæsar came to it, armed with present glory, and with a steadiness of purpose and action all his own. So confronted, it could not be doubtful how the contest between these two great Romans would end.

These views of the character of Pompey, and the doubt whether he held any settled scheme of political action, are mainly derived from the writings of Cicero; his advocate, as far as circumstances made it possible to be so — an advocate, or an accuser, not merely with his own time, but with all succeeding ages! In the case of this eminent man, also, a bold and skillful pen is wanted to serve the cause of strict historical truth, without needlessly offending opinions which have gained a sanction from the general adoption of posterity. The character of Cicero, as drawn by our author, is not altogether such a picture as might have been desired: neither his merits nor his foibles are brought out with sufficient force. Little is said of the consummate grandeur and completeness of his oratory, though upon these performances his glory mainly rests. His philosophical and purely literary works hardly add to his real fame, though they do not deduct from it. His epistles, admirable as documents of character and manners, are so at the cost of his personal reputation. Vanity, pedantry, feebleness of will, and feebleness of endurance, all stand in record against him under the unconscious testimony of his own pen. Such is the evidence, that we are forced, despite ourselves, to apply it to the greatest

act of his public life, and to doubt whether his conduct in the Catiline conspiracy was all that he himself has depicted it to be. This doubt is strengthened from other historical sources; and the acclamation which hailed him 'Father of his Country' was probably a cry of momentary impulse, which a year later dwelt in few memories but his own. He met his death, indeed, with fortitude; but even here we have it from a high contemporary authority that 'it was the sole calamity which he bore as it became a man to do.'

Incomparable as an advocate, these other and lower qualities, and a certain jealousy as to his origin, forbade his ever attaining the highest position as a statesman, especially at the time of revolution in which his lot was cast. We have various proofs that Cæsar and Pompey thoroughly understood all his foibles, and worked upon them for their own purposes. To the masculine vigour and singleness of Cæsar's mind, in particular, they appear in remarkable contrast, and there is curious evidence how much the orator stood in awe of the great commander even before his career of victory had begun. We can well believe that the latter must often have smiled at the mixed humility and vanity of Cicero's communications with him; — the submissiveness of a conscious inferiority in will and action — the vanity of a man whom it is painful to call a pedant, but who in reality was such. In the midst of Cæsar's last Spanish campaign, one of the most critical of his life, Cicero introduced to him a young man, named Præcilius, in a letter interlarded as thickly with Greek phrases and quotations as is a modern fashionable novel with French; and, it must needs be added, with as little pertinency or fitness. It is true that he calls it *genus novum litterarum*; but still we feel it strange that such a letter should have been written by Cicero, and addressed to Cæsar.

There is something of moral wrong in indiscriminate praise as in indiscriminate censure. To this further reproach we

fear that Cicero must be submitted. He was δεινος επαινετης in the strongest sense of the phrase. His speeches against Verres, Catiline, and Antony, show how large an armoury of caustic language he had at command. But in his epistles and elsewhere, we find the most copious collection of laudatory terms in existence — one, indeed, that has served as a lexicon to the learned flatterers of every later time. It is impossible not to see that he generally praises with a reflex view towards himself. He is governed much more by the seduction of his own style than by the reality before him. If the letters of introduction, of which he is so liberal, were but half true as to the virtues of those recommended, Rome could not have been so speedily submitted to the servitude which now hung over her.

The character of Cato is not formally brought forward by our author among those of the other great actors of the time. This we regard as an omission. He is one of those personages in history who have become, in some degree, the property of the poet and the moralist, and respecting whom there is a conventional language of panegyric not wholly in accordance with the rough and rude reality. The succeeding part of Mr. Merivale's narrative, in as far as it relates to the Roman Stoic, shows what the truth of history requires to be deducted from common repute regarding him.

The account of the intrigues and combinations which produced the first Triumvirate is clear and forcible. It was an unprincipled cabal, annulling by a transient union the real powers of the constitution, while keeping up its outward forms. The interests of the senate and nobles were sacrificed by one triumvir; those of the people by another; while the third ministered to the alliance that power which wealth gives in a corrupted state. What individual ambition could not yet effect, was attained by this conjunction. It was the empire of Augustus by anticipation, and conducting to this as

a natural result. But it wanted that stability which unity of person and purpose alone afford, and was dissolved by the separation of the same ambitious interests which had created it.

The first effect of the Triumvirate was to give to Cæsar the Consulship, which he could not otherwise have obtained. He was regarded by the aristocracy of Rome as too dangerous a representative of the doctrines and acts of the Gracchi and Marius to admit of their acquiescence in the power which this office conferred on him. But the power was got; — the colleague whom they thrust in to cripple it thrown violently aside; — and the position of Cæsar further confirmed by the marriage of Pompey with his daughter. The uxorious temperament of the latter offered a pledge and security to Cæsar, during the long absence from Rome which was close at hand as the first act in his higher career. This career now lies before us in a more definite form than heretofore; and, though more or less familiar to all, yet, considering the grandeur of the man, the greatness of what he accomplished, and the influence this has had upon all succeeding ages, we may be excused for dwelling at some length on the subject. It occupies, indeed, more than one half of the volumes before us; and we cannot hesitate in admitting that Mr. Merivale has done it full justice. He rises in vigour as he gets free from the complex intrigues of the city, and embodies in his narrative that series of stirring events which carried Cæsar to single supremacy. To these events we would now seek to direct attention.

We have before noticed several foreign works, and particularly those of Meissner and Drumann, in which the life, character, and policy of Julius Cæsar are fully and ably handled. In England we are chiefly indebted to Dr. Arnold and to Mr. Long for what we possess on this subject; and in

Mr. Merivale's preface he warmly and gracefully acknowledges the aid he has derived from the writings of the former on the later commonwealth of Rome. Of the original materials for the life of Cæsar, we have little room and not much occasion to speak. They are well known to scholars in their different degrees of value and authenticity. We may well regret here (as so often elsewhere), the lost books of Livy, whose personal knowledge of those who had witnessed or partaken in the acts of this eventful period, would have given still deeper interest and charm to his narrative power. We should willingly recover from the spoils of time the history of Asinius Pollio, the cynical companion of Cæsar in all his most arduous campaigns; and the letters and biography of Atticus, the tranquil observer and common friend of all parties, even when factions were fiercest. Yet more should we wish that the stern truth and lofty moral dignity of Tacitus could have been applied to the life of a man who made such mighty changes in the destinies of his country. These are vain aspirations; yet in some sort forced upon us when disheartened by the disputable stories of Suetonius, Plutarch, Dion Cassius, and other anecdote-mongers of antiquity. The authority of Appian is abated by distance of time and other doubts as to his histories. The little we have from Sallust upon this period the bias of the writer compels us to receive with caution. The Pharsalia of Lucan may not safely be taken as more than subsidiary authority to facts recorded elsewhere; though we are unwilling to utter anything in depreciation of this fine composition, which we can hardly agree with Quintilian in regarding rather as oratory than poetry. The materials which come to us for the life of Cæsar most free from cavil and doubt are his own Commentaries, and Cicero's Epistles and Orations. The former, whatever their merits, cannot be rescued altogether from the charge of partial representation. The latter need to be read with a critical eye, from the pecu-

liarities of Cicero's character, and his political position in regard to the great men who figure in the events before us.

The early life of Cæsar affords two or three anecdotes which we cannot well distrust, seeing how entirely they accord with his later acts. His bold and successful collision with Sylla, then in the fullness of power and enforcing his will with blood,— and the chivalrous transaction with the Cilician pirates,— are instances of the strong determination, self-confidence, and personal intrepidity so amply shown in the sequel. The moral courage of the youth is said to have drawn a prediction from Sylla of the future fortune of the man. Such stories are often begotten by the event; but we can easily believe that Sylla might discover in a character having so much kindred with his own, those elements which are sure to be effective in a State bordering on dissolution.

The other information we possess as to the early part of Cæsar's life, with the exception of his study of rhetoric at Rhodes, places him before us as a reckless spendthrift, a city voluptuary, a fearless politician and partisan. His relationship to Marius gave name and foundation to a course of action which he would probably have pursued had no such connection existed. For though, in this instance also, we think Mr. Merivale too decided in assigning motives and method to political conduct, yet we cannot doubt that Cæsar, conscious of and confiding in his own powers, and observant of the decay of ancient institutions and ancient republican virtues around him, must have felt that a great arena was open to the exercise of these powers, and to the ambition which their possession was sure to inspire. Under such impressions he took the line of party most natural to him as the nephew of Marius, and offering a surer road to influence than the adhesion to a jealous, intriguing, and tottering aristocracy. Without pretending to affirm it, we see no cause to suppose more of scheme or foresight than this in Cæsar's

early public life. He flung himself upon the tide of events then rushing stormily on — prepared to stem it with strong arm and heart of controversy — but yet unaware how he should be carried forwards, or on what shore his fortune would cast him.

This broad view tallies better, we think, with Cæsar's character and the records of his early life, than any more refined speculation as to his political and personal objects at this period. The juvenile excesses related of him were due in some part, probably, to physical constitution — an element never to be disregarded in forming such estimates; — in part, perhaps, to the desire of warding off suspicion at a time when the hand of power was strong against his party. We have already had occasion to comment on the frequent error of historians in regarding character as single and unchangeable, and parcelling out their theory of motives and events accordingly. The mind of Cæsar was as entirely individual, as little touched by time or changed by circumstances, as any on record. But it is perfectly consistent with this to suppose that his views were enlarged, and their direction determined by events themselves. The ambition with which he was early charged, he undoubtedly had; seconded by a strong and consistent will and high intellectual power; — and these qualities sufficiently defined his course in the existing state of Rome. He seems to have avoided any direct connection with the profligate plots so frequent at this period. We doubt his being otherwise concerned in that of Catiline than as a too indulgent spectator of scenes which might open new avenues to his own ambition. During the career of Clodius he was absent from the city; but he signalised himself by his efforts to shelter his political adversary, Cicero, whom Pompey, professedly a friend, betrayed to the violent demagogue. His own measures in the popular cause, both before and during his consulship, appear to have been in themselves

neither intemperate nor unreasonable. His period of government in Spain was successful in arms, able in administration. But this was his sole independent command before the Gallic war; and when we compare his early course with the wide career and large renown of his rival, yet find them equally associated in the Triumvirate, we see that Rome had already learnt to know the loftier character and higher resources of Cæsar, and that this position was one which could not safely be denied to him.

In his fifth chapter, as an introduction to the Gallic campaigns of Cæsar, Mr. Merivale gives an able and lucid history of the great Celtic race, which in its different branches and at successive times came into urgent collision with Rome; — once putting her very existence at stake, and often inflicting panic by the conjunction of these northern hordes with the Italian states hostile to the Republic. The last great alarm from this people had been the irruption of the Cimbri, in transient connection with certain Teutonic tribes, into Italy and Southern Gaul; — a gigantic armed migration, which swept away more than one Roman army, and required the strenuous arm of Marius to arrest it. Bloody victories, ending in massacres, satisfied the dignity and restored the safety of Rome. It was reserved for the greater nephew of Marius to complete the work on the soil of Gaul itself, and by the conquests of successive campaigns to bring the whole of this warlike country in subjection to the Roman power; — a splendid achievement, and, from the causes just mentioned, duly estimated at Rome. The formidable king of Pontus, a worthy rival in arms to Sylla and Pompey, had disturbed only the distant possessions of the Republic. The Gauls once reached the Capitol, and still stood at the mountain gates of Italy, menacing her provinces, and requiring the constant watchfulness of her legions.

These Gallic campaigns of Cæsar, extended through his

long proconsulship of nine years, splendidly illustrate the genius and resources of the man; and throw, moreover, a curious light on the still remaining institutions of the Republic. As proconsul, and with provinces and legions allotted to him, the law forbad his going out of the limits thus assigned. The City was interdicted to him; and for this long period of time — though forty years of age when this portion of his career began — he never entered the place in which the interests of the world were concentered. Yet in no other way could his ambition have been better served. The active part of each year was passed with his legions in marches and victories, and in the acquisition of spoils, with which to purchase further power. Leaving his army under his lieutenants at the end of the campaign, to be recruited and refreshed, he came himself each winter to the frontier of his province nearest to Rome, where he was met by his numerous friends and partisans from the city, animated by his conquests and increasing fame. His military court there had more validity in it than the habitual presence of his rival in the heart of Rome. It now became a contest between living success on the one side, and the memory of past achievements on the other — a contest which the world will ever decide in the same way: —

> To have done is to hang
> Quite out of fashion, like a rusty mail
> In monumental mockery.

The resistance of the Gauls might possibly have been prolonged, or more successful, had they been familiar with the methods of guerilla warfare. But either from temperament or national custom, they aggregated themselves into masses wholly incapable of withstanding the organised valour of the invaders. The history of the tenth legion is familiar to every reader of these stirring campaigns. Cæsar was well

served by his generals as by his soldiers. Yet, as in the case of Napoleon's marshals, their fame was little more than the reflection of his. Labienus, the most noted of them, deserted the standard of Cæsar at the time he passed the Rubicon; an act which served but to show how entirely it was the spirit of the great commander which ruled and invigorated his army. Though Labienus served the enemies of Cæsar until he perished in the battle of Munda, his name never again appears before us associated with any great action of war. Other causes may be conceived for this; but the main one doubtless was, the absence of that inspiration which came from the genius of Cæsar.

Our author's account of these military transactions is spirited, and fairly illustrated by reference to existing localities; though such is the life which illustrations of this kind impart that we could have wished them carried still much farther. We draw our chief acquaintance with the Gallic wars, it is needless to say, from the books which have come down to us under the name of the great chief himself. His Commentaries have ever held a high place among historical records; and no wonder, considering his fame, the masculine simplicity of his writings, and the greatness of the deeds recorded. Even here, however, the bold spirit of modern criticism has flung its doubts on the theme of our schoolboy exercise and delight. We have already adverted to a general suspicion of partiality in the narrative. Other charges have been made impeaching the accuracy even of the military details, which we are surprised to find that Mr. Merivale passes over without notice. Long ago M. Puysegur, a French general, had broached this scepticism as to certain parts of the work. Frederic of Prussia, sceptic and warrior by profession, and fresh from his own bloody campaigns, avowed that he read the Commentaries in later life with altered faith from that of his earlier days. His friend

Voltaire — if we may thus profane the name of friendship — living close to the scene of the actions recorded in the first book; and Warnery, upon a minute survey of the same localities, started grave scruples as to the operations by which Cæsar sought to stop the egress of the Helvetians from their mountain territory.* Various passages in the other campaigns have been the subject of like criticism, and doubts even stated as to the authorship of the whole work. In these doubts we cannot acquiesce. Without referring to those other writers, Rohan, Guichard, &c., who have vindicated the military narrative, we find in Cæsar's Commentaries a perfect reflection of the energy and intelligence of the man, and an entire correspondence with the description which Cicero gives of their style: — *Nudi sunt et recti et venusti, omni ornatu orationis, tanquam veste, detracto.* We cannot, indeed, conceive any other or lesser artist to have thrown off so completely all ornamental colouring from his narrative, and to have preserved such entire unity throughout the whole. And what record or note has there been left to us of such other author? We may admit the recorded criticism of Asinius Pollio, that many things were written by Cæsar from the report of others long after the events, and still see in these Commentaries the genuine work of Cæsar himself, and one of the most authentic and valuable records of ancient warfare.

But passing over this question of criticism, there is no question as to the fact that, in eight or nine years, with a force never exceeding sixty thousand legionary soldiers,

* The great stumbling-block here is the fortified wall, reported to have been built to bar this passage; 19 miles in length and 16 feet in height, with ditch, and all other appurtenances to such fortification. The length is deemed by Warnery to be refuted by local circumstances. The execution of the work by one legion, in the time indicated, is thought impossible by others. See on this subject an interesting series of papers in the 'United Service Magazine' for 1850.

Cæsar subdued the whole of Gaul — a mighty and a terrible work. We do not give ready belief to historical numbers, more especially when fields of battle are concerned; but where the struggle was so fierce, and the conquest so complete and lasting, we are obliged to think it probable that the estimate of more than a million of Gauls perishing in these campaigns is not above the truth. It is one of the many unhappinesses of war in every age, that by its absolute or supposed necessities, it leads to acts of cruelty and bloodshed, even where most alien to the feelings of those who conduct it. We have no reason to charge the character of Cæsar with inhumanity, or that gross indifference to human life which Marius and Sylla displayed throughout. On the contrary, we have many instances on record of his personal humanity and forbearance. But the history of these Gallic wars is undoubtedly one of profuse bloodshed; — the natural result of a struggle between disciplined legions and undisciplined multitudes; — of critical positions in the midst of an enemy's country, *necessitas in loco, salus ex victoriâ*; — of exasperation of the soldiery; — and of intimidation used as an instrument of success. Our vindication can go no further than this; unless, indeed, we were to find it in a parallel with the wars of Frederic and Napoleon, an argument upon which we have neither room nor disposition to enter.

The two invasions of Britain and the passages of the Rhine are episodes in his history, chiefly remarkable as proofs of the indomitable boldness of Cæsar who thus adventured on new lands while those behind him were yet but half subdued. In the fame however, and the fear which followed these deeds, he found an ample equivalent to the risk incurred. At Rome, as well as in Gaul, his passage to Britain was a step towards empire; while, to a mind thus instructed and enlightened, there must have been a further interest in this new land and people beyond the sea. We possess some

curious evidence from astronomy to show the time and place of his disembarkation in Britain — evidence which may well excite the wonder of those who know not how physical science triumphs in its proofs, even upon the most obscure historical questions; and how deeply chronology is indebted to eclipses and the recorded places of stars for some of its happiest discoveries. Our scientific readers are well aware of the method which Halley applied to this particular calculation; indicating the beach at Walmer or Deal as the place of landing of the Roman legions, and not Hythe, as others from an expression of Dion Cassius had supposed.* From his castle at Walmer the illustrious Warden of the Cinque Ports looked down upon the spot where Cæsar probably first trod the soil of England: — himself equal to Cæsar in military fame and success; — superior to the Roman, as to all other commanders, in those loftier virtues of a citizen which have secured to him the lasting gratitude of his country.

We must, however, hurry forward to those remaining events in the life of Julius Cæsar, occupying only a few years; but years of marvellous activity and success; which brought him to the very steps of the throne he was not

* The single statement of a full moon occurring on the fourth night after Cæsar's arrival off the cliffs of Dover gives basis to the calculation. His passage across the Channel was made early in the morning of the 26th of August. That retrospective reckoning, which is one of the prime powers and wonders of astronomy, enabled Halley to determine that there were two full moons in August, 58 B.C.; and the narrative shows the last of these, at midnight on the 30th, to be the one recorded. The course of proof then turns to the tides. On the 26th the tide must have begun to flow at Dover at 2 P.M., running northward round the South Foreland. The fleet left its moorings off Dover on this tide, and the length of course Cæsar describes would very exactly suffice, under ordinary circumstances, to bring them to the flat beach of Walmer or Deal. M. Saulcy, in a work just published (1862), also contends for Deal as the landing place. But on the other hand the present Astronomer-Royal — a high authority in all ways — considers that the coast about Pevensey answers better to the indications which the narrative affords us (Archæologia, vol. xxxiv.); while Mr. Lewin, in a recent work, argues with ability that the place of disembarkation must have been in the vicinity of Romney.

destined himself to fill. The defeat and death of Crassus in his Parthian expedition changed the name of the Triumvirate, but hardly affected the real contest for power, which remained, as before, between the two great military chiefs — Pompey in the city, Cæsar in his camp. Jealousies and causes of rupture multiplied as time went on. The death of Julia — more deeply lamented, it would seem, by the husband than the father — broke asunder one bond of union between them. The anarchy in Rome, fomented rather than repressed by Pompey, had placed him in the condition of sole Consul of the Republic; — an anomalous admixture of old institutions with the aggressions and tyranny of the existing time; and certain not to subsist long, when so palpable a fiction in itself, and so entirely opposed to the interests of his matchless rival. On the side of Cæsar, the spoils of Gaul were poured into the city as bribes and largesses. The tribunes were gained to his cause; supporting his claim to a participation in the extraordinary powers thus conceded to Pompey, and to a second consulate, while still holding his province and absent from the city: — demands adverse alike to the letter and spirit of the constitution, and sanctioned only by the breaches already made in it. The claim of Cæsar was refused, as he probably anticipated, under the influence of the senatorial party. He passed the Rubicon, the limit of his province; — boldly, as was his wont; but deliberately, as we are told, and with full knowledge of the importance of an act which has served ever since to describe those steps of bold adventure from which there can be no retreat. His march upon Rome and occupation of the city, while the great strength of his army was yet far distant, were marked by the same dauntless determination. In sixty days from the passage of the fatal streamlet he was master of Italy. The conduct of Pompey in evading the first struggle of arms has been variously explained. Whatever the impulse

or urgency of the procedure, it was a proof of present disability; disheartening to his adherents and a source of dissension to the party. Though a vast body of senators clung to his flying camp, it was the Senate of Rome no longer, and brought neither counsel nor strength to his cause.

At this time, when the Duumvirate resolved itself into a personal contest between the two leaders, we may believe that the views of Cæsar had become more exactly defined; and that he saw as the needful issue, the mastery of one or the other over the whole fortunes of the Republic. Now, if not before, we may suppose him to have uttered the lines which Cicero tells us were often on his lips, from the Phœnissæ of Euripides, that 'if ever it be fitting to commit wrong, the noblest motive for this is the gain of sovereign power.' Hastening forwards with the tide of events, we find them all still marked with the character of the man, ever more energetic and capable as the difficulties were greater. While Pompey was loitering with his senators and troops in Epirus, Cæsar pushed across the Alps and Pyrenees into Spain;—subdued in an arduous and critical campaign of forty days the large legionary army opposed to him on the Ebro;—overcame the remaining Pompeian forces on the Guadalquivir;—and, when hardly yet known to be on the shores of the Atlantic at Cadiz, suddenly appeared at Marseilles to decide the surrender of that city, long vainly besieged by his subalterns. To estimate rightly what such marches and victories were, it is needful to revert to the aspect of these countries at the time, to the state of the mountain roads, to the dangerous and scanty means of navigation on the seas. When we are told that Cæsar himself often crossed rivers by swimming on inflated skins, overtaking his own couriers in the speed of his course, we can form some idea of the difficulties encountered, and of the personal energy by which they were overcome.

After quelling by his single presence and speech a mutiny of some of his legions at Placentia, he reappeared at Rome; confirmed his authority there by wise and salutary acts; and then, with such part of his army as he could collect in time, threw himself suddenly upon the coast of Epirus, there to confront for the first time his great adversary. A protracted contest followed near Dyrrachium, of refined strategy and alternate blockade by sea and land. The inferiority of Cæsar's force, even after being joined by fresh legions, exposed him to a severe check, which had the effect of suddenly transferring the war across the mountain barrier of Pindus to the plains of Thessaly. Here the momentous battle of Pharsalia closed the struggle, and decided the fortunes of Cæsar. His hardy legions, like the iron regiments of Cromwell, confident in their commander, won complete victory over the numerous but more courtly and effeminate army opposed to them. The field is to this day unchanged in its main features. The stream of the Enipeus is still seen winding across it; a village occupies the site, and yet bears the name of Pharsalus. We ourselves have twice trodden over this ground, and been able to note, without any great ambiguity, the main localities of a conflict thus famous in history.*

Cæsar permitted no pause in the pursuit of his rival, or in the interest of his own career. With a hardihood which might be censured as rashness, were it not so constantly justified by success, he was still ever in advance of his army.

* Mr. Merivale's account of the battle is somewhat obscure in its topography. His supposition of change in the course of the Enipeus is not necessary to reconcile Cæsar's narrative with the actual localities. The vestiges of the ancient walls of Pharsalus around the modern village, the position of the several hills bordering the Enipeus to the south, and the interval between these hills and the stream, all accord with the events as described to us by Cæsar. On this subject we may best refer to the authority of Colonel Leake. In a memoir published by the Royal Society of Literature, this most learned and accurate scholar satisfactorily illustrates the whole campaign, and very especially the battle of Pharsalia, upon his personal knowledge of the ground.

Rapidly traversing Thrace and Asia Minor, he embarked for Egypt, where, though he found Pompey slain, no meaner talent or fortitude than his own could have saved him from the peril to which he exposed himself amidst the populace of Alexandria, infuriated by his bold demands and interference with their national affairs. Rescued from this danger, the history of Cæsar for a moment changes its complexion. We find the warrior and statesman yielding himself to the blandishments of Cleopatra, and the companion of the Egyptian queen in the lawless and luxurious revelries of the East. We hardly know in what degree this picture has been coloured by hostile scandal or poetical embellishment. Both, we suspect, have been at work with the story; though we must add that Mr. Merivale gives larger belief to it, and describes the character of Cæsar as permanently changed by the vices and indulgences of his Egyptian life. Thus he says, in a passage with which we cannot readily agree —

> But the sorceress of the Nile had not only corrupted the Consul's patriotism; she had enchanted him with the poisoned cup of Canopic luxury. She had taught him to despise as mean and homely the splendour of the Circus and the Capitol; she had imbued him with the gorgeous and selfish principles of Oriental despotism, and debased him to the menial adulation of slaves, parasites, and eunuchs. . . . . If from henceforward we find his generosity tinged with ostentation, his courage with arrogance, his resolution with harshness; if he becomes restless and fretful and impatient of contradiction; if his conduct is marked with contempt for mankind rather than with indulgence to their weaknesses, it is to this impure source that the melancholy change is to be traced.

We confess that we always view antithetical writing with distrust; nor do we find in the remaining acts and events of Cæsar's life any evidence sufficient to justify the conclusion here denoted. Though by no means exempt from human weakness, we believe him to have been a man who could dally with luxury and flattery without being subdued by

them. We find him breaking loose from these supposed bonds on the first intimation of a war in Pontus, rushing with his usual rapidity to this distant contest, and ending it with more than his usual speed and success. What our author calls his 'arrogant bulletin' — the famous *veni, vidi, vici*, of this war — is a story too variously told by the writers of the time to admit of its being brought in evidence against Cæsar. Nor have we proof that he sacrificed any real object of his policy either by this dalliance in Egypt, or by the later visit of the Egyptian queen to Rome. Mark Antony might lose his world for Cleopatra: — Cæsar could not be thus conquered. Yet, while rejecting the probable exaggeration of anecdote and poetry, we cannot willingly part with the whole of the picture handed down to us. A passage of Suetonius places before our imagination a barge on the Nile, bearing the splendid freight of Cæsar and Cleopatra — the majestic Roman who changed the face of the world, noble in person and feature, great in intellectual power as in war — and the royal sorceress of Egypt, bent to win her splendid prize, and by the very witcheries which long after led a conqueror captive to his ruin. But we need for such a scene as this our own Shakspeare; whose gorgeous picture of Cleopatra on the Cydnus is one of the many marvels in his unapproached delineation of this woman; — a portraiture ranking as a whole among the truest and most felicitous of all his wonderful works.

Scarcely had the untired Cæsar reached Rome from his victory over the son of Mithridates in Asia, when he set forth again with his army for Africa to encounter the powerful force collected there by Cato and Scipio. The conflict at Thapsus closed the campaign at once; and gave a motive, though we are far from believing a necessity, to the tragic end of Cato. On this subject Mr. Merivale puts before us a striking and eloquent passage.

From Africa Cæsar returned to Rome, and celebrated there a quadruple triumph of greater magnificence than any that had gone before, but with all the strange and ferocious exhibitions belonging to this festival. It was a needful concession to national usage; — whether made willingly or not, we have no means of affirming. Much discretion was required in the selection of the subjects for triumph; since civil wars had been so closely interwoven with foreign, that his greatest exploits and successes were studiously kept out of sight. And scarcely indeed were these shows ended, when he was again summoned to the field to put down the large insurrectionary army which the sons of Pompey had assembled in Spain. In twenty-seven days — *celeri festinatione*, as his historian well says — he was with his forces in Andalusia. The bloody but decisive day of Munda, where 30,000 soldiers were left on the field, and the victor himself exposed to imminent personal danger, closed this last formidable antagonism and the military life of Cæsar. It is a point of time when even those who most deprecate war in all its forms may look back with astonishment, if not with admiration, at the wonderful career of victory so terminated. Whether we consider the vast countries and distances thus traversed in Europe, Africa, and Asia,— the battles gained, — or the conquests effected, we cannot but feel that Cicero has well applied the term of τερας to express the activity, the vigilance, the sagacious daring of Julius Cæsar. He is indeed a *prodigy* in the history of mankind.

After his final campaign he returned to Italy: this also was for the last time. Though absent for many months, the awe inspired by his name had protected the city against all turbulance or innovation; and he now came back, single and supreme, the arbiter of the future destiny of Rome and the known world. Already three times declared Dictator, he was now named such for life. The consulship was given to

him for ten successive years; a crown of laurel and triumphal robes were allotted to his public appearances; his head, for the first time, was stamped on the public coinage. All these things were outrages on old custom and feeling: — they betokened the greatness of the change not less than of the man who had brought it about. The title of Imperator given at the same time, had much less import and weight then, than it has since obtained. Though never before *prefixed* to a name, it avoided the odium which was still attached to the style of King. But associated as it was in Cæsar with more than regal power, it became the badge of high sovereignty, and descended through a long line of Roman Emperors (or those so called) to the times in which we now live.

This last epoch of Cæsar's life, at which we arrive, was of little more than eight months' duration. It was occupied in various useful reforms and legislation; the sequel in principle to the measures which at prior times he had proposed, or partially carried into effect. He indulged the people with the sports and shows which usage and policy required; but his aims were evidently beyond these things; and from what he actually did, we have reason to believe that though his destined term of life was nearly completed, his designs were far from being so. We have no exact knowledge of the date of his several measures; but as far as we can see, they had for their basis the establishment of order in the City and provinces, the suppression of existing abuses, and the change or extinction of those old institutions which were now effective only in lending a shelter to them. His liberal extension of the rights of Roman citizenship was but a sequel to the policy of his whole life on that point; and the result doubtless of his conviction that what was not yielded peaceably would be, sooner or later, extorted by violence. The large increase of the Senate, and the admission of numerous

foreigners into this body, while it seemed to repair the breaches made by the civil wars, and flattered the new citizens from the provinces, was virtually an annihilation of this part of the old Roman government, already debased by luxury and intrigue, and incapable of fulfilling its ancient functions. With this same view probably, he shortened the term of the Consulate; an office which was now sought for by turbulence and bribery, and exercised only for party purposes. The consular and prætorian provincial governments were also abridged in duration; for the wise purpose of checking the gross speculations and abuses which had grown up in this part of the Roman administration. Larger admission was given to all public offices, with less limitation as to rank and age; a measure which tended to destroy the influence of those great families (*præclaro nomine tantum insignes*) who made their ancestral fame an avenue to public functions, which they dishonoured by their acts. As Censor, Cæsar enacted certain sumptuary laws which, had he lived, he would doubtless have enforced; and began various improvements in the judicial system, and especially in criminal law. He established colonies of veteran soldiers on a plan which procured exemption from many of the disorders consequent on long civil war. He appointed a commission, and furnished a scheme for a land-survey and map of the whole Roman dominion; and with the same zeal for practical good and knowledge of the resources of science, he accomplished that reform of the Calendar which alone would have preserved his name to posterity.

While thus indicating the general principles upon which Cæsar guided his government, there remains the curious enquiry — What would have been his own future course and position in it, had his life been prolonged? Master of the Roman world he was:—Master he must have continued, under one title or other. No conspiracy by open arms could have suc-

ceeded, or been attempted, in the face of his military renown; and the resignation of Sylla, of which he is said to have spoken disdainfully, could never have seemed to him other than a warning; — since it had given fresh scope to those civil disorders which he, above all men, knew the necessity of bringing to an end. His personal ambition doubtless here concurred with, and strengthened these convictions of his reason. But power, even the most entire, cannot well subsist without some external form or title; and the *turba Remi* resembled the populace of every age and country. We know not how far the story of the kingly crown being offered to him, and of his reluctant refusal of it, is worthy of reliance; but we suspect that the officiousness of friends, or the malignity of enemies, were more concerned in this matter than the will of Cæsar himself. There never was a man less governed by mere phrases, or who would more readily abandon an outward show for the reality that was before him. The new *prefix* of Imperator sufficed for the designation of that power, which, in default of direct issue, he would probably have conveyed downwards to the very successor on whom future events actually conferred it. We further believe, on all the evidence of his acts and character, that his own rule would have been one of vigour, tempered by moderation and humanity, — of firmness to repress sedition, — and of wisdom to organise new institutions where the old ones had become impotent for good.

Two anecdotes, unconnected with politics, belong to this last period of Cæsar's life, which have the greater interest from the time of their occurrence. One is the narrative, contained in a letter from Cicero to Atticus, of the visit paid by the great master of Rome to its great orator, at his villa near Puteoli. The details of the interview, and the dinner given to the Dictator and his numerous attendants, illustrate most agreeably the manners of the day; but far more

strikingly describe the two remarkable men thus brought together for the last time; — both deeply concerned in the public events of the preceding twenty years,— both destined to perish by a violent death. We would willingly invite the attention of those of our readers who may have forgotten it, to this curious and characteristic letter. We have always been especially entertained by the frank confession of Cicero to Atticus, that Cæsar was not a guest to whom he could say 'Pray, pay me another visit on your return'—(*semel satis est*); and also by his acknowledgement that no serious matter (*σπουδαιον ουδεν*) was discussed between them, but that the conversation turned mainly on literary topics. The motive for this restraint may readily be found in the history of the time, and in the relative position of Cicero and his great visitor: — the direction of the conversation, we doubt not, rested entirely with the latter. Even with such restraint upon it, who does not wish that a Boswell had been present to record what passed? * The other anecdote to which we allude, has less certain authority for its truth but great internal probability. Cæsar was the guest of M. Lepidus at supper at Rome. After the repast, a conversation arising on the question which was the most desirable manner of death, the Dictator pronounced as his opinion that it was 'the one most sudden and unexpected;' — a sentiment natural to the man, and which, in a qualified form, was afterwards repeated by his first successor in the empire.

On the very day, as we are told, after this supper, Cæsar's life was ended by that murder which seemed at the time fated to change the condition of the world. It would be difficult indeed to name any single incident of deeper interest.

* We gather further from this letter, that Cæsar had other and more ordinary powers of making himself an agreeable guest at dinner. 'Edit et bibit *αδεως* et jucundè; — opiparè sanè, et apparatè.' We are surprised that Mr. Merivale should so slightly press this curious document of Roman life.

On the one side we have the character and dignity of Cæsar, the power he had acquired, and the prospect of this power being permanent as a new form of Roman rule: — on the other side, the publicity of the assassination, and the condition and qualities of the men whose swords were thus

made rich
With the most noble blood of all this world.

The death of Cæsar, like that of Cato, has almost lost its historical character in the poetry and romance of later times, which have appropriated to themselves an event thus signal in all its circumstances. Shakspeare probably comes nearest, as he generally does by his almost superhuman instinct, to the reality of the case. His Cassius, too, is at once a faithful transcript from history, and a picture of the jealous and ambitious conspirator of all ages. The Brutus of his play was necessary to the dramatic effect which he so well understood; and accordingly we find that, while closely adhering to historical truth in most parts, he has pitched the character of the Roman patriot somewhat higher than the level assigned by contemporary authorities. History has been defined 'philosophy teaching by examples;' but we have little faith in the force of such examples, as opposed to living and current events; and, removing all artificial colouring from the act before us, we are disposed to regard it as the result of jealousy, ambition, and other personal feelings, much more than of the pure love of liberty or the desire of restoring the grandeur of Rome. The assassination of Cæsar inflicted another civil war on the State, without really retarding the great change which was on the eve of accomplishment. Had his life been prolonged, it is probable that his enlightened vigour of administration would have given a better basis to the empire, and a higher model and precept to his successors, than the more subtle and temporising reign of Augustus was able afterwards to afford.

This act of blood closes the narrative now before us;—our author's final chapter being occupied by a delineation of the character of Julius, and of the condition of Rome at the time of his death. The former subject has been variously handled, according to the complexion of the writer's mind, or that desire of framing a theory of motives and events which is so often observable in those who undertake to record them. We have no desire to shelter moral failings, or to palliate the evils arising from ambition and war; yet we must express our belief that Dr. Arnold has coloured his Cæsar too darkly. Mr. Merivale is less austere; and a passage at the beginning of the third chapter, shows his comprehension of those high qualities which designate to all posterity this greatest of Romans. We have, however, to complain that his portraiture is somewhat broken and unconnected, giving the feeling of a certain want of congruity; and occasionally it would seem that even a line of Lucan, or an anecdote of Suetonius, has sufficed to produce a change of opinion. In one place, for instance, he speaks of the 'perfect simplicity of Cæsar's character;' in another, of 'his gratuitous indulgence to his passion for personal display;'—qualities hardly compatible in themselves, even with every allowance for those disparities of which we have elsewhere spoken. That the error lies in the latter passage we entertain no doubt. The mind of Cæsar had, we believe, very much more of singleness and consistency than is often met with in history; but the events and conditions of his career were so various and extraordinary, that it would require much critical research and discrimination to present a picture of him which might satisfy all the requirements of truth. On the whole we may say, without attempting such an analysis, that while his public course during the last sixteen years of his life was one of almost constant and bloody warfare, his natural temperament seems to have been hu-

mane, and free from that remorseless cruelty which stained the career of so many of the public men of his age. Whatever of moral contradiction there may seem in this, experience teaches that the conditions are compatible; and in the instance before us we have proof sufficient to justify the opinion given. The '*gaudensque viam fecisse ruinâ*' of Lucan is the phrase of the poet, and not the truth of the historian. Amidst the thousand private animosities which civil wars engender and envenom, we do not call to mind a single action of Cæsar prompted by private malice or revenge; — many of humanity and generosity to enemies who fell within his power. Whether he was a man of warm affections may admit of more doubt. We incline to think not; though without any certain evidence by which to decide the question. He had several friends indeed — Oppius, Calvena, Balbus, &c. — who were deeply attached to him; and various acts of his personal kindness to them and others are on record: but his superiority to all around him was such, that it is difficult to measure the feelings in this case by any ordinary rule. All the strongest traits of Cæsar's mind were intellectual; and we doubt whether softer sentiments, passion, or romance, had ever any very strong hold upon him. A tragedy, indeed, was among the number of his literary works; but it no longer exists, nor have we any such accounts of it as to affect our guesses.

The profligacy of his early course — partially, as it seems, carried on into his later years — has been a main allegation against him in all succeeding times. We cannot accuse him of intemperance at table, since Cato remarks that he was 'the only one who went forth sober to the overturning of the commonwealth.' But the charges of other sensuality admit no excuse or palliation; unless we find such in the general corruption of the age, or in some suspicion that the public eminence of Cæsar might have led to exaggerated

statements of all that regarded his demeanour in private life. Making every allowance for such over-colouring, however, we are still unable to dismiss the general imputation. Temperament, temptation, opportunity, were all on one side, without a single aid from religion or moral discipline on the other. Two or three small incidents are presented to us as proofs of superstitious feeling; but we believe them to have depended rather on a politic or careless conformity to popular sentiment; for Cæsar lived, as Virgil did,

Al tempo degli Dei falsi e bugiardi;

and it was impossible that an acute intellect like his should have submitted itself for a moment to the puerile absurdities of the Grecian or Roman belief, or derived motives to virtue from sources thus scanty and impure. He lived without religion, on the very verge of that time which brought new light and truth into the world.

As to the intellectual qualities of Cæsar, it is needless to say more. They are inscribed on every page of his life and history, and are the subject of constant admiration to his contemporaries as well as to succeeding writers. A single sentence of Cicero, than whom no man was better entitled to judge, is a relation to all future time of that combination of faculties which has rarely, if ever, had its parallel: '*Fuit in illo ingenium, ratio, memoria, litteræ, cura, cogitatio, diligentia.*' Pliny, in his Natural History, recording the most noted examples of intellectual power, instances Cæsar as possessed of an innate vigour of mind transcending all others; able without confusion to embrace various subjects at once, to dictate clearly on each, and to pass with the celerity of lightning from one to another. Omitting the many other testimonies of the same age, we may take the eulogy by Drumann as a brief and just statement of what was achieved in various ways by this wonderful force and capacity of mind.

'He was great in everything he essayed: as a captain, a statesman, a lawgiver, a jurist, an orator, a poet, a grammarian, a mathematician, and an architect.' We have only to object to this eulogium that it assumes a parity of excellence in points where we must suppose that there was much real inequality. But nothing is stated here which Cæsar did not actually accomplish; and his mind rose so high above mediocrity, that, even where our evidence is imperfect, we can believe some part of his genius to have been conveyed to all he undertook.

With the exception (and this a doubtful one) of Frederick of Prussia, Cæsar is perhaps the only great commander who adds the fame of literature to that of war. Near the close of his career he established a Greek and Latin library at Rome, selecting Varro as his librarian. Unhappily all his writings are lost to us except the Commentaries; a fact which, regarding the author both in his own greatness and as the head of a long line of sovereigns, may reasonably excite surprise as well as regret. We are indeed imperfectly informed as to the mode in which the manuscripts, forming the literature of those days, passed into circulation and were transferred from one generation to another; but still it must appear strange that so large a part of the writings of a man like Cæsar should have disappeared from the world. It is related that he composed his grammatical treatise, *De Analogiâ*, while travelling through the Alps; and a poem called *Iter* during a journey in Spain. The former was dedicated to Cicero; and from a fragment of it still preserved, we find that Cæsar first proposed the name of *ablative* for a case not known to the Greek Grammar. Looking at other points in his character, we are half inclined to believe that he wrote them solely for his amusement while on the road; and that, indifferent to literary fame, he took little care to multiply the copies which might secure transmission to later times.

Of his other writings we most covet the satire of the Anti-Cato, the treatise on Auguries and Presages, and his tragedy of Œdipus. We venture no opinion as to the probable merit of these works, beyond the general inference already stated; but may hazard a conjecture that the poetical and imaginative part would have added least to his reputation. Niebuhr has somewhere remarked that there is no witty saying of Cæsar on record. It is difficult enough to define wit in any form, and we should hardly go to a German professor for aid in the definition; but if pithy and pointed expressions and retorts come under the term, we know that Cæsar had such at command. Some specimens live indeed in every scholar's memory; and if his collection of apophthegms — the *mucrones verborum*, as Lord Bacon calls them — had reached us, we should probably have had abundant evidence of his keen apprehension of those great sayings, which form the true wit of every time and language of man.

We are surprised that Mr. Merivale takes such slight notice of the oratorical fame of Cæsar, seeing the strong impression it made upon the best judges of his own age and country. Where Cicero and Quintilian have testified their admiration in terms so remarkable, it is hardly enough to despatch the subject in a short sentence, without reference to these eminent authorities. From one passage in the *De Claris Oratoribus*, it may be seen how high a value Cicero attached to the opinion of Cæsar regarding his own oratorical powers. What other commander or conqueror, how few statesmen even, have obtained or merited tributes like these, and given by such judges! * Nor can we fail to notice the portrait they convey to us of the noble aspect, attitudes, and voice of

* 'Cæsar autem, rationem adhibens, consuetudinem vitiosam et corruptam purâ et incorruptâ consuetudine emendat. Itaque cum ad hanc elegantiam verborum Latinorum adjungit illa oratoria ornamenta dicendi, tum videtur

Cæsar, when addressing an assembly. We are able in great part to complete the picture of his outward lineaments from busts, coins, and actual description; all which indicate, as far as mere outline can ever do so, the high intellect and masculine vigour of mind belonging to this wonderful character.*

We have, we hope, shown that we are disposed to augur well of Mr. Merivale's large and bold undertaking. We shall look with interest to his next volumes, as the history of that subtle Sovereign who, under the specious show of old names and forms, succeeded in giving to a disputed and divided power all the unity and integrity of an ancient monarchy. The character of Augustus, in his successive capacities of Triumvir and Emperor, has ever been counted an historical problem; and with every allowance for the frailty and changes of our nature, it still is not easy to reconcile all the incongruities which the acts of his life bring before us. Beyond this period, our author will acquire the aid of Tacitus to his labours; — an authority and a guide not less admirable than is Thucydides to the historian of Greece; — both possessing qualities which may well serve as instruction to those writing history in all time to come. Without

tanquam tabulas benè pictas collocare in bono lumine. * * * * Splendidam quendam, minimèque veteratoriam rationem dicendi tenet, voce, motû, formâ etiam magnificâ et generosâ quodammodo.'— *Cicero de Claris Oratoribus.*

'Quem huic antepones eorum, qui nihil aliud egerunt? quis sententiis aut acutior aut crebrior? quis verbis aut ornatior aut elegantior?'— *Ibid.*

'Caius verò Cæsar si foro tantum vacasset, non alius ex nostris contra Ciceronem nominaretur; tanta in eo vis est, id acumen, ea concitatio, ut illum eodem animo dixisse, quo bellavit, appareat.'— *Quintilian*, lib. 10.

It is obvious that Quintilian would not thus have expressed himself, unless some at least of Cæsar's speeches had been extant in his time.

* It is satisfactory to me to find in the great work of Mommsen on Roman History, recently published (*Römische Geschichte*, 1857), an entire concurrence of opinion in all that relates to Cæsar's character and career; and a like agreement in the estimate of his great rivals and contemporaries.

exacting from our author the rigorous brevity of Tacitus, which would be rendered impossible by a regard to modern taste, as well as to the larger field of critical history over which his course lies, we still think that something may be gained from this great model; whom it is impossible to study without acquiring vigour from his style; or without sympathising in that high spirit of philosophy, and utter disdain of all that is false and frivolous in the world, which marks everything he has written.

PHYSICAL GEOGRAPHY OF THE SEA — THE ATLANTIC OCEAN.*

[Edinburgh Review, April, 1857.]

In the earlier days of this Review the teaching of geography, as then understood and practised amongst us, was a dry and barren task; tedious to the teacher, distasteful and of slender profit to the scholar. Bald catalogues of easily forgotten names (*locorum nuda nomina*, as Pliny calls them), uninformed by science and scantily illustrated by history, formed the staple of the study. Nor was any part of education more defaced by the coarser mechanism of bookmaking. Errors of fact, and even of nomenclature, were perpetuated from one edition or compilation to another; with little regard to original accuracy, or to the changes going on in the world. And even where some fragment of history or physical science broke in upon the network of names, it was often of doubtful authenticity, or too partial and detached to give real knowledge or gain hold on the memory. This is not an exaggerated view of the manner in which geography was generally taught in England down to a recent period.

The more exact study of history had already improved the

* 1. *The Physical Geography of the Sea.* By Lieut. Maury, U.S. Navy. London and New York, 1856.

2. *Considérations Générales sur l'Océan Atlantique.* Par Philippe de Kerhallet. Paris, 1853.

methods, and extended the sphere of geography, before physical science had fairly annexed itself to the subject; creating new associations of high interest in themselves, and fertile in their influence on the condition and welfare of mankind. Humboldt is the philosopher who has especially contributed to the establishment of physical geography as a branch of science. The natural phenomena, indeed, upon which it is founded, being ever present and patent to observation, could not have escaped record; and this record was becoming continually more copious through its connection with other branches of natural knowledge. But there was yet wanting a clear specification of the scope and objects of the science thus gradually evolving itself; and of the methods best fitted for their attainment. It is this which we owe to Humboldt's peculiar genius, aided by the vast resources

earth, ocean, and atmosphere all come within its sphere, as well as those great and mysterious forces — gravitation, heat, light, and electricity — by which these several portions of our planet are so powerfully and incessantly acted upon, it will be seen how closely the subject is linked with every other research into the world of nature around us. Our countrywoman, Mrs. Somerville, has well expounded these relations in her admirable volumes on Physical Geography. The Physical Atlas of Berghaus, a valuable German work, preceded the publication in this country of the more extensive and elaborate 'Physical Atlas of Natural Phenomena' by Mr. A. Keith Johnston, of which it would be difficult to speak in terms above the mark of its actual merits. Embracing every part of the subject, it delineates to the eye as well as the mind — and far better than by any verbal description — those complex relations of physical phenomena on the globe, which are the true foundation of Physical Geography.

Of all branches of science, no one contributes so largely to our knowledge of the actual condition of the globe as Geology. By drawing its conclusions from a long series of ages, this science has given us the means, in no other way equally attainable, of studying and explaining the present aspects of the earth we inhabit. Such are, the power obtained through the study of fossil remains, of identifying strata in localities the most remote, and thus fixing the common epoch (however long its duration) of certain states or changes of the crust of the globe; — the facts discovered, which prove the gradual upheaval of portions of the earth's surface and the slow depression of others; — the proofs from the inclination and contortions of strata, from the alterations of the older strata, and from the position and elevation of the unstratified rocks, that other changes, more abrupt and violent, have occurred from subterranean forces of expansion or

contraction;—the evidence derived from the direction, parallelism, and other aspects of mountain chains, as to periods of contemporaneous elevation;—the influences upon climate of lands elevated above the sea or depressed below it;—and further, the whole history of that coral creation, by which, under the slow working of microscopic forms of animal life, islands and reefs are raised from the depth of the ocean, to become the habitation of other and higher existences.

We have thus far spoken of Physical Geography in its largest acceptation. It has, however, of late been submitted to a process of division, made needful by the multiplicity of the objects it includes; and the phrase of 'Physical Geography of the Sea,' proposed by Humboldt, is the title of the first of the works now before us. Under this title its author, Captain Maury, of the United States navy, includes all that concerns the great domain of waters over the globe;—the oceans, seas, and basin lakes into which they are distributed;—their various depth, temperature, and saltness;—the currents which permanently or periodically pervade them;—the phenomena of the tides;—the phenomena of winds, whether constant or irregular, whether the steady trade breeze, or the hurricane and cyclone;—the law of evaporation belonging to different latitudes of the watery world;—the less known, yet certain agency of magnetic or electrical forces;—and the mutual influence of ocean and land in all these physical actions and changes. This summary statement shows how vast and various are the objects in the division of science thus proposed. We find further reason for its adoption in the importance of all these objects to the principles and practice of navigation;—a matter of supreme weight in these days, when the ocean in its every part is covered with ships; shaped in new forms, moved by new forces, destined to new shores, and seeking to attain by new routes the highest speed of transit. Facts and phenomena, before unobserved or bar-

ren of result, are now eagerly appropriated; and, by the science and ingenuity of man, made to minister to the purposes of human intercourse over the globe. The ocean, once an obstacle, has become the high road of nations. If steam has worked its wonders on the land, so it has also on the sea; and under a form surpassing, in grandeur of force and effect, all the other operations of this great agent of human power. Iron, that material which ministers in such endless ways to the uses of man, has scarcely less efficiency on the ocean than on land; and we have at this moment in progress before our eyes, gigantic applications of it to the building and propulsion of vessels, both of war and commerce, such as the world has never before seen.

Acquiescing fully, then, in the name and distinction of 'Physical Geography of the Sea,' we may add that we consider Captain Maury a worthy interpreter of the great phenomena included under this title. Attached as Superintendent to the National Observatory at Washington, he has used this honourable position, with much zeal and intelligence, in forwarding objects of singular importance to his own country and to ours, and of general interest to all nations of the world. He published some years ago his 'Wind and Current Charts,' a valuable precursor of the present volume. To his assiduity we owe that conference held at Brussels in August 1853, in which were found representatives from England, France, the United States, Russia, Sweden, Denmark, Holland, Belgium, and Portugal; — occupied, at the very time when war sternly impended over Europe, in organising plans for those cooperative labours on the ocean; those methodical records of winds, currents, tides, and temperature, which provide for the peaceful interests and progress of commercial navigation over the globe. Austria, Prussia, the Hanse Towns, Spain, and Brazil, subsequently offered their cooperation in the same great scheme. With observa-

tions thus multiplied on every side — the log even of the common merchant brig being admitted to its share in the work — facts will speedily become numerous enough to yield results of the highest certainty and value. The method of averages, now so potent an aid to research, has especial application here, furnishing a secure approach to conclusions which no detached observations could reach.

Though Captain Maury claims all seas for his province, the larger portion of his volume is occupied with the great Ocean which separates the Old from the New World; a very natural effect of the supreme importance of the Atlantic to the commerce of nations, and of the greater knowledge thus attained of all its physical phenomena.* Considered as a scientific treatise, our author has not done full justice to himself, or to his subject, by his manner of dealing with it. We are unwilling to be hypercritical where there is so much real merit; but it is impossible not to see in his work a desultory desire for novelty, frequently going far beyond the bounds of true science, and venting itself in a phraseology which loses its force and effect by being too sedulous to attain them. With a little more constraint upon his speculations, and a clearer separation of fact and hypothesis, he would be a valuable scientific writer. With somewhat less intention of fine writing, he would be an eloquent one.

It is with reluctance that we advert to another characteristic of this volume: — we mean the very frequent and incautious reference to passages in Scripture; not solely for illustration, but even as authority for physical truths, or argument for hypotheses still unproved. Lieut. Maury is evidently a man of strong and sincere religious feelings, and

* It will be seen that we have given place on our list to another work, by Captain Philippe de Kerhallet of the French Navy, having more especial relation to this Ocean; less scientific in its character than that of Captain Maury, and less animated and vigorous in its descriptive part, but nevertheless containing much that is of great practical value for navigation.

we honour the earnestness with which he expresses them. But he unhappily does not see that in forcing Scripture to the interpretation of physical facts, he is mistaking the whole purport of the sacred Books. In thus appropriating their language, he annuls its bearing on matters of deep concern by applying it to objects and cases of totally different nature. This *pia deflexio*, as it has been termed in instances of more serious import, must ever be regarded as an injury done to real religion; and we are anxious now, as at all times, to enter our remonstrance against it.

The passages thus misapplied are chiefly taken from the Old Testament — the Psalms, the Book of Job, &c., — which, in the pictures they give of the works and wonders of creation, need borrow nothing of that science they do not profess, to render them to all ages the most sublime eulogies of the power and wisdom of the Creator. One example only we will cite, to show how much of error may enter into this loose method of dealing with scriptural authority. After a passage, too laboriously ornate in its diction, where our author speaks of the allusions in the Bible to the laws of nature as involving, under figurative language, hidden meanings which are only disclosed by the later revelations of science, he quotes among other instances the striking text from Job (xxxviii. 31), '*Canst thou bind the sweet influence of the Pleiades?*' or, as he gives it, '*Canst thou tell the sweet influence of the Pleiades?*' And this sublime but obscure interrogation he considers as solved by the recent views of Professor Mädler of Dorpat, which represent the star of Alcyone in the Pleiades as the centre of gravity of that vast sidereal system, to which our globe belongs as a small and subordinate planet.

Here we must remark, but without wonder or reproach, that he is ignorant of the controversy as to this text, which has engaged the learning of Gesenius, Rosenmüller, Mason-

Good, Herder, and other scholars; leaving the interpretation still very ambiguous. He seems himself to have quoted from some translation which doubtfully takes half the sense from the Septuagint (*Συνῆκας δὲ τὸν δεσμὸν Πλειάδος*); omitting altogether the conception of a *link* or *binding together*, which is kept in our authorised translation, and which so happily applies to the close and beautiful aggregation of stars in this group; — an aggregation of such kind that astronomers have calculated the chances to be more than half a million to one, that they could not have been thus set in the heavens by accident alone.

The latter part of the passage in question is also of doubtful interpretation; and we may well ask therefore, whether this is a text upon which to establish or confirm a physical fact? But, further, our author assumes in his argument that Mädler's conception of the Pleiades, as the centre of the sidereal system, is 'all but proved;' forgetting or ignorant that few astronomers have recognised it as more than a magnificent problem awaiting solution from future research. Sir J. Herschel especially has given a distinct reason for distrusting this opinion, in the distance of the Pleiades from the plane of the Milky Way; which plane must presumably coincide with and define that of any general movement of rotation in the stellar system, should such exist. The science therefore of this comment is as doubtful as the scriptural quotation to which it is appended.

It may seem that we have dwelt too long on this matter; but we must repeat in justification our earnest desire that the authority of Scripture should not thus rashly be pledged to facts and opinions with which it has no concern, save in so far as it describes the visible manifestations of creative wisdom, beauty, and power. The example just given we consider to be an apt illustration of the errors usually committed in this method of argument. Though less frequent

than formerly, we still find them in some controversies of recent date; gaining a prompt influence over the public mind; as injurious, we believe, to the interests of religion as of the sciences thus forced into contact with it.

We come now, and with more satisfaction, to the legitimate object of Captain Maury's work, — the great watery empire of the globe; the aspects and phenomena of oceans and seas; their various physical relations, as well to the continents and islands they encircle, as to the atmosphere incumbent over all; and that farther relation they bear to the efforts of human industry, intrepidity, and skill, which have rendered the most distant paths of ocean open and assured to all nations of the earth. The Atlantic is the especial object of our author's labours; and accordingly we find the first parts of his volume occupied almost exclusively with this ocean. Though we may explain the preference, we cannot wholly acquiesce in it as preliminary to a physical history of the sea at large. The subject requires to be prefaced by those more general views of the distribution and relative configuration of water and land over the globe, which form the very foundation of physical geography, and are fertile in curious and important conclusions. Facts which, if stated at all, are loosely and incongruously scattered over the volume, ought to have been put before the reader in some connected form; as indicating the nature and magnitude of the objects concerned. Captain Maury plunges him at once into mid-ocean, without compass or guidance over its world of waters. A greater familiarity with the writings of Humboldt, Ritter, Von Buch, and other authors, principally German, who have done so much for the study of physical geography, would have furnished both model and materials for a preliminary chapter, such as we desire for a work bearing this title and dealing with objects so vast and various in kind.

We may cursorily state here, in illustration, a few of those

general facts, to which our author might fitly have given the priority suggested. First, the proportion of sea to land, determined as being nearly three to one;—or in other words, three-fourths of the surface of the globe is actually covered with water. Next, the fact (important in suggesting a disparity in the physical forces which have acted on the two hemispheres) of the great excess of land in the northern hemisphere over that of the southern, being in the ratio of 11 to 4;—on which condition depend the curious results that only 1-27th part of existing land has land diametrically opposite to it in the other hemisphere, and that the line of the equator, as it girdles the earth, rests on the ocean for five sixths of its length. Another mode of estimating the proportions and local relations of land and sea is obtained by halving the globe longitudinally on the meridian of the Canaries; when a much larger proportion of sea will be found on the western half or hemisphere so defined, than on the eastern. The main fact of the great predominance of water on the surface of the globe being thus proved, and its mean depth, as we shall see hereafter, approximately determined, we reach other conclusions of high interest to every department of physical science. We shall notice only one of these, in which geological theory, both past and prospective, is more especially concerned. The *mean elevation* above the sea level of all the land on the globe—islands as well as continents, mountains as well as plains—is estimated by Humboldt at somewhat less than 1,000 feet. The mean depth of the great oceans of our planet is calculated by Laplace, from the tides and other phenomena, to be at least 21,000 feet. Hence, allowing full margin for errors, the entire submergence of the land might take place, leaving the solid mass of the earth everywhere deeply covered with waters—an elliptical globe of ocean, moving still under the influence of the same sublime laws which had before guided its path through surrounding space.

This is enough to show what we should have desired as a foreground to the topics of Captain Maury's work. There is undoubtedly much to justify his partiality for the Atlantic as a subject for illustration; and we shall follow his example by limiting our remarks still more exclusively to what concerns this great Ocean — a volume itself in the 'physical geography of the sea.' Indeed, our author devotes his first two chapters to a single current of the Atlantic; but this current, under the name of the Gulf-stream, includes physical conditions so remarkable that we cannot blame the priority thus given to its history. To use his own words: —

> There is a river in the ocean. In the severest droughts it never fails, and in the mightiest floods it never overflows. Its banks and its bottom are of cold water, while its current is of warm. The Gulf of Mexico is its fountain, and its mouth is in the Arctic Seas. It is the Gulf-stream. There is in the world no other such majestic flow of waters. Its current is more rapid than the Mississippi or the Amazon, and its volume more than a thousand times greater. Its waters, as far out from the Gulf as the Carolina coasts, are of an indigo blue. They are so distinctly marked, that this line of junction with the common sea-water may be traced by the eye. Often one-half of the vessel may be perceived floating in Gulf-stream water, while the other half is in common water of the sea; so sharp is the line and such the want of affinity between these waters; and such, too, the reluctance, so to speak, on the part of those of the Gulf-stream to mingle with the common water of the sea.

This passage delineates, in terms happily chosen, some of the most striking features of this wonderful stream. But there are yet others to be noted; and we shall dwell somewhat in detail on a natural phenomenon thus remarkable: — one, moreover, in which we, the people of the British Isles, have a direct and momentous interest, as well in reference to commerce and navigation, as to its certain and various influences on the climate under which we live.

The general description of the Gulf-stream, apart from any present question as to its sources, is that of a vast and rapid

ocean-current, issuing from the basin of the Mexican Gulf and Caribbean Sea; doubling the southern cape of Florida; pressing forwards to the north-east in a line almost parallel to the American coast; touching on the southern borders of the Grand Banks of Newfoundland, and at some seasons partially passing over them; — thence, with increasing width and diffusion, traversing the whole breadth of the Atlantic, with a central direction towards the British Isles; and finally losing itself by still wider diffusion, in the Bay of Biscay, on our own shores, and upon the long line of the Norwegian coasts. Its identity in physical characters is preserved throughout the many thousand miles of its continuous flow! — the only change undergone is that of degree. As its waters gradually commingle with those of the surrounding sea, their deep blue tint declines, their high temperature diminishes, the speed with which they press forwards abates. But taking the stream in its total course, it well warrants the vivid description of our author, and the name he bestows upon it of 'a river in the ocean.' This epithet (bringing to memory the ροὴ Ὠκεανοῖο of Homer), is in truth singularly appropriate to this vast current, so constant and continuous in its course, and so strangely detached from the great mass of ocean waters; which, while seemingly cleft asunder to give path to its first impulse, are yet ever pressing upon it, gradually impairing its force and destroying its individuality.

The maximum of velocity, where the stream quits the narrow channel of Bemini which compresses its egress from the gulf, is about 4 miles an hour. Off Cape Hatteras in North Carolina, where it has gained a breadth of 75 miles, the velocity is reduced to 3 miles. On the parallel of the Newfoundland Banks it is further reduced to 1½ miles an hour, and this gradual abatement of force is continued across the Atlantic. The temperature of the current undergoes similar change. The highest observed is about 85° Fahr.

Between Cape Hatteras and Newfoundland, though lessened in amount, the warmth of the stream in winter is still 25° or 30° above that of the ocean through which it flows. Nor is this heat wholly lost when it reaches and is spread over the coasts of Northern Europe. The waters, thus constantly flowing to us from the tropical regions, bring warmth as well as abundant moisture to our own islands; and Ireland especially, upon which they more directly impinge, doubtless derives much of its peculiarity of climate — its moisture, verdure, and abundant vegetation — from this source. Were it needful to seek proof of the permanence of the great natural phenomenon of which we are speaking, we might find it in those curious passages of ancient geographers — (Pomponius Mela, and J. Solinus Polyhistor, for example) — which describe the peculiarities of the Irish soil and climate eighteen centuries ago, almost as we should depict them now. But the influence of the Gulf-stream does not stop even here. The climate it may be said to convey is diffused, more or less, over the whole Norwegian coast; the aspects and produce of which singularly contrast with those of the corresponding latitudes in North America, Greenland, and Siberia. Other causes doubtless contribute to this effect; but none, we apprehend, so largely or unceasingly.

The influence of the temperature of the Gulf-stream upon animal life in the ocean is very curious. The whale so sedulously shuns its warm waters, as almost to indicate their track by its absence; while yet abundantly found on each side of it. The physical reasons are doubtless the same which prevent this great marine mammal from ever crossing the Equator from one hemisphere to the other — a fact now well ascertained. The various species of fish, which are firm and of excellent flavour in the colder belt of sea upon the American coast, lose all their good qualities when taken out of the Gulf-stream, running closely parallel to it. On the

other hand, the more delicate marine productions, whether animal or vegetable, which multiply and prosper by warmth, are redundant in the Gulf-stream even after it has quitted the tropical regions whence its heat is derived. The food is thus matured for the whale-field of the Azores, where this huge denizen of the seas flourishes in colder waters amidst the abundance so provided.

Our author describes yet other peculiarities of this wonderful current. Its waters are found to be warmest at or near the surface, cooling gradually downwards, so as to render it probable that there is a layer or cushion of cold water between them and the solid earth which lies below. Again, the surface of the stream is shown to be not strictly a plane; but having its axis or central portion raised somewhat higher than the level of the adjoining Atlantic; thus giving it a sort of roof-shaped outline, and causing the surface water to flow off on each side. The existence of such surface current has been proved by boats floated near the centre of the stream, which drift either to the east or west, according to the side of the axis on which they may be. This curious fact has been attributed to the central waters of the current being warmest, and therefore of least specific gravity. It may be so; but we cannot altogether discard another physical cause; viz. the enormous lateral compression exercised upon the stream by the ocean waters through which it forces its way; tending to *heap it up* towards the axial line. Those who have beheld the wonderful spectacle of the Niagara River, four miles below the Falls, — so urged and compressed into a narrow ravine that the middle of the stream rises twelve or thirteen feet above the sides, — will be able to conceive this hydrodynamic influence, even on the wide scale of operation which we have now before us.

There is some evidence that the waters of the Gulf-stream, when emerging from the Caribbean Sea, are salter than those

of the Northern Atlantic through which they flow. But as the difference scarcely exists half a per cent., we hesitate in believing, with Captain Maury, that this greater saltness is the sole source of the deep blue colour they assume. We receive, too, with distrust his speculations on what he considers the probable '*galvanic qualities*' of this great stream. We have little doubt, indeed, that the electrical element, pervading in one or other of its forms the whole material world — giving motion and change to masses as well as molecules, and evolved or altered itself by every such motion and change — may have some concern, as cause or effect, in the natural phenomenon before us. But we perceive at the present time so much tendency to make use of this great power as the basis of vague and fruitless speculation, that we are always suspicious in the outset, when we find its agency invoked to solve a physical problem. In the present case we see no especial reason for having recourse to it. The physical conditions of the Gulf-stream — its definite direction, its force, its temperature, its saltness, its relation to Atlantic winds and storms, and its tardy intermingling with the mass of ocean — may be referred, with more or less probability, to other natural causes in certain and constant operation. We cannot exclude electricity from the number, but we must not invoke it on the slender evidence which our author places before us.

These considerations lead us to the theory of the Gulf-stream; a matter on which a good deal has been written; and speculations put forward on very insufficient proof. Such is, the early opinion that it owes its origin to the river waters of the Mississippi, forcing a sea current before them out of the Gulf-basin — an opinion at once refuted by the utter disproportion between the alleged cause and the observed effect. It would, in fact, be the case of 300 volumes of water put into rapid motion by one volume only — such,

according to Livingstone's careful estimate, being about the proportion of the gulf to the river stream. Another hypothesis, again, to which the names of Dr. Franklin and Major Rennell give some sanction, assigns a higher level — a *heaping up*, as it were, of the waters in the Gulf of Mexico, in effect of those forced into this great basin by the trade-winds of the Atlantic — thereby giving to the Gulf-stream the character of an immense river descending from this higher level to a lower one. Captain Maury suggests, we think, valid objections to this hypothesis; and even contends, from the relative depth of the stream in the Narrows of Bemini and of Hatteras, that instead of *descending*, its bed represents the surface of an inclined plane with a descent from north to south, *up* which plane the lower depths of the stream must ascend. We are bound to say that he does not replace, by any complete theory, the opinions which he thus annuls. Nor is it, in truth, easy to frame one which shall meet all the conditions required, seeing the present imperfect state of our knowledge of the mutual influence and action of the mighty agents concerned in such phenomena — the ocean, the atmosphere, the rotation of the earth on its axis, the change of seasons, the tides, the heat and cold of different regions, and possibly other influences, of the obscurity of which we have just spoken. All who are familiar with the science of Hydrodynamics and the theory of waves, know that these subjects involve problems requiring for their solution the highest mathematical power, based upon the most exact experiment and observation; questions which have exercised the genius of Euler, Lagrange, Poisson, Prony, Cauchy, Weber, Venturi; and in our own country, of Brindley, Smeaton, Young, Scott Russell, and others. The theory of the Gulf-stream has close connection in many points with these high problems, while at the same time complicated by its manifest relation to the great natural agents just named.

We must, then, excuse in our author his somewhat desultory view of a phenomenon, of which no single or simple explanation can rightly be given. It is certain, from the permanent characters of the Gulf-stream, that he is correct in treating of it as part of a great *circuit* of waters in the Atlantic, determined and directed by natural causes of constant operation. One main influence we may presume to be, the tendency of the polar and equatorial waters to exchange and equalise their temperature by currents flowing at different depths through the ocean; — a condition certain to exist, and well illustrated by the phenomena of those constant or periodical winds, which fulfill a similar object, by maintaining the needful balance of temperature in the great *atmospheric sea* around us. Nor is this reference to the trade winds one of analogy only. We cannot doubt that they are concerned in keeping up the flow of those vast equatorial currents which, traversing the Atlantic from the African coasts, are pressed into the Caribbean Sea and Mexican Gulf on their southern side; and sweeping round this great basin and its islands, are mainly discharged through that narrow passage between Cuba and Florida, where the name of the Gulf-stream is first attached to the current. All its characteristics may best be explained under this general view. If a mass of waters be constantly thrown into the Gulf, a mass of waters must as constantly find exit from it. If the exit be narrow, the force of the stream will be proportionally augmented, by the unceasing pressure from behind; rendering it powerful and persistent enough to cleave the waters of the ocean; making a return path for itself to the more northern parts of the eastern hemisphere, and carrying thither the warmth derived from the eternal summer of the equatorial seas.

We can have little doubt that this outline conveys the true theory of the Gulf-stream; associating it broadly with those

great currents of circulation over the globe, which we know must be the certain effect of differences of temperature, but which may in part also depend on the diurnal rotation of the earth, affecting the rate of motion and direction of such currents as they flow through different latitudes. The Arctic current setting into the Atlantic from Baffin's Bay, and transporting huge icebergs to be dissolved by the warmer seas of the South, is well known as a branch of one of these circuits. The existence of a similar circulation of waters in the Pacific — the other great ocean which stretches from pole to pole of the globe — though less defined in its details; comes in confirmation of this view. It is more directly corroborated by the old experiment of casting bottles into the sea containing dates of place and time; which transported in silent, slow, but certain course, give information to watchful observers on distant seas or shores. These mute interpreters of natural phenomena often render better service to science than the thoughts or theories of man. The chart drawn up by Admiral Beechy, representing the tracks of more than a hundred bottles, shows that all the equatorial waters of the Atlantic tend westwards towards the Mexican Gulf, to issue thence in the Gulf-stream. Those thrown overboard in mid-ocean, or on any part of the African coast, have been found after a certain lapse of time either in the West Indies, or on the British shores, or floating in the course of the Gulf-stream between. There is even reason to believe that some of these bottles have been discovered on their second circuit; arrested probably on the coasts of Spain by the drift southwards, carried along the African coast into the equatorial seas, and thence againacross the Atlantic to the Gulf of Mexico. The first among the valuable plates appended to Captain Maury's work, clearly shows the course thus indicated, and illustrates the whole scheme of the mighty currents we have been describing.

Whenever a circuit of waters is thus formed we have every reason, from tidal and other analogies, to look for an intermediate or central space, comparatively calm and motionless. And such a space is actually ascertained to exist within this great Ocean whirlpool. The 'Mar de Sargasso,' as the Spanish navigators termed the central portion of the Atlantic, stretching westwards from the Canaries and Cape Verd Islands — a surface fifteen times greater than that of Great Britain — may be described as a vast stagnant pool, receiving the drift seaweed, which the surrounding currents fling into it, and generating on its calm surface what has been well called 'an oceanic meadow' of seaweed, the *fucus natans* of botanists. It is in this tract of sea that we find such wonderful species of fuci as the *Macrocystis pyrifera* — having stems from 1,000 to 1,500 feet in length and but a finger's size in thickness, branching upwards into filaments like packthread. This vast domain of marine vegetable life is the receptacle, as indeed are the waters of the ocean generally, of an equal profusion of animal existence — from the minute luminiferous organisms, which (to borrow Humboldt's phrase) 'convert every wave into a crest of light,' to those larger forms of life, many of which derive nutriment from the waters alone, thus richly impregnated with living animal matter. Reason and imagination are equally confounded by the effort to conceive these hosts of individual existences — *cette richesse effrayante* as Cuvier terms it — generated or annihilated at every passing instant of time. No scheme of numbers can reach them, even by approximation; and science is forced to submit its deductions to the general law, that all the materials of organic life are in a state of unceasing change, displacement and replacement — under new forms and altered functions — for purposes which we must believe to be wisely designed, but which transcend all human intelligence.

It is interesting to possess a record of this Mar de Sargasso

from the pen of the great mariner who first traversed it on his way to the discovery of a new world. In a letter written by Columbus in 1498, he relates that in each voyage from Spain to the Indies, he found, about 100 nautical miles to the west of the Azores; a wonderful change in the aspect of the ocean; so sudden, too, that he uses the word *raya* to mark the line of boundary. The sea became at once calm and still, scarcely even moved by storms; but so thickly and strangely matted over wth seaweed, as to suggest instant danger to the ships from running upon shoal banks. Nearly four centuries have elapsed since these phenomena were present to the eager and observant eye of Columbus; and they still continue as they then were. The same currents sweep round the basin of the Atlantic; the same stagnant and weedy sea still exists within the circuit of waters thus formed. How changed, meanwhile, the aspect of man's existence on the shores which bound this ocean; and how certain the greater changes during the ages which lie before us! Many of these changes, and such as may count among the mightiest now in progress, are due to the Atlantic itself, and to that permanence of its physical characters which we have been describing. Not only has it served to the intercommunication of the two hemispheres, but it may almost be said to have created the Western, by the tide of human emigration carried across from the old world to the new. Some of the greatest problems in government and social existence are awaiting their eventual solution in the races thus transplanted; and especially in the powerful nation, our own immediate offspring, established on the wide and fertile continent of the West.

We cannot touch upon this vast topic of human transit over the Atlantic, whether for commerce or migration, without recurring once more to the history of the Gulf-stream. Though in practical navigation its influence must have been often felt,

yet this fact was scarcely recognised or distinctly recorded before the time of Franklin, whose sagacity, applied to certain special cases, showed him at once the value of a more exact knowledge of all belonging to this great current. One of these cases is curious enough to deserve mention. When in London in 1770, he was consulted as to a memorial sent from Boston to the Lords of the Treasury, complaining that the packets from Falmouth were generally a fortnight longer in reaching Boston than common traders from London to Rhode Island, a passage fully 300 miles longer. Captain Folger, a Nantucket whaler, who happened to be then in London, was questioned by Franklin, and furnished him with the true explanation. The Rhode Island traders were acquainted with the Gulf-stream, and kept out of it. The captains of the English packets, from ignorance or carelessness, or possibly seduced by the more genial temperature of this southern course, ran their vessels into the current and *against it*; making a difference in some parts of their voyage of not less than fifty or sixty miles in the daily run, besides the loss incurred from sailing in a lower latitude. Dr. Franklin made Folger, whose experience taught him to avoid a stream in which whales are never found, trace out on a chart the course of this ocean current, had it engraved, and sent copies to the Falmouth captains. These gentlemen, wedded to their old ways, or perhaps despising their informant, took no notice of the suggestion and went on as before.

Franklin was also the first to indicate the temperature of the Gulf-stream, as a valuable aid to the navigation of the Atlantic, especially on the American coasts; the dividing line between the warm stream and the cold waters of the ocean which hem it in, being so precise as well as constant, that the longitude may often safely be inferred from it. Captain Maury affirms and, we doubt not, with truth, that

this dividing line never changes its position in longitude as much as mariners then erred in their reckoning. He gives us also a very curious account of the relation of the Gulf-stream to the storms and hurricanes of this ocean, to which is due their frequent character of rotatory storms or *cyclones*; a name well adapted to the remarkable phenomenon so described. One passage here we will transcribe from our author.

I am not prepared to maintain that the Gulf-stream is really the 'Storm King' of the Atlantic, which has power to control the march of every gale that is raised there; but the course of many gales has been traced from the place of their origin directly to this stream. Gales that take their rise on the coast of Africa, and even as far down on that side as the parallel of 10° or 15° north latitude, have, it is shown by an examination of log-books, made straight for the Gulf-stream: — joining it, they have then been known to turn about, and travelling with this stream, to recross the Atlantic, and so reach the shores of Europe. In this way the tracks of storms have been traced out and followed for a week or ten days. Their path is marked by wreck and disasters.

One such storm commenced more than a thousand miles from the Gulf-stream, made a straight course for it, and travelled with it for many successive days under the conditions of a whirlwind or cyclone. A fearful disaster, due to one of these hurricanes, occurred in 1853, to the steam-ship 'San Francisco,' carrying a regiment of United States troops from New York to California. Overtaken by the storm in crossing the Gulf-stream, 179 souls, officers and men, were swept overboard and perished. In this case, the knowledge possessed of the stream, its limits, direction, velocity, &c., greatly aided what was done for the discovery and relief of those who survived. The import of these and similar facts to the future guidance of Atlantic navigation will readily be understood. It may be hard to account for them in theory, but their practical value cannot be doubtful or mistaken.

Intending, as we have said, to confine our remarks chiefly to that ocean on which Captain Maury himself best loves to expatiate, we shall follow him more cursorily through the other parts of his volume. Three chapters of his work relate to the Atmosphere, in its various connection with the physical geography of the sea,; as expressed by the phenomena of winds, of evaporation, of rains, of temperature, of fogs, and of electrical changes; — a vast subject, and not less complex than vast. Multiplied though all its records have been of late years, and made more minute and accurate as well as numerous, Meteorology cannot yet take its place among the exact sciences. We have just named some of the topics it includes; but there are yet others, which mix with and complicate all the results of observation. The weight of the air is one of these; an element involved as effect or cause in almost all other atmospheric changes, and deeply concerned in any theory of the winds. Again, we have those conditions of Electricity, which are expressed by the wonderful phenomena of magnetism acting through and upon all parts of the globe, solid, fluid, and aërial; and brought before us under a new aspect by Professor Faraday's discovery of the magnetic properties of oxygen as modified by heat. Even that other subtle element of Light — if indeed it be another and separate element — may in some sort affect the atmosphere, through which its action is transmitted to the earth and ocean below. As associated with, or, according to our recent philosophy, *converted into* heat, there can be no doubt of this influence. But the marvellous results which science has obtained from the chemical actions of light, justify the belief that other analogous effects may exist, though yet hidden from human observation. If electric states of atmosphere are able to convert oxygen into Ozone, light, in its different degrees of intensity, cannot well be supposed without influence, even on the inorganic parts of the aërial medium

through which its passage lies. We know well its wonderful power in evoking the organic life, with the germs of which the atmosphere everywhere teems; and there is even reason to believe that this influence extends to different depths of the sea, concurring with other causes to define those successive *strata* of animal and vegetable life, which are so curiously attested as the result of the marine dredgings and soundings directed to this object.*

We deviate thus far from our direct subject, merely to point out the singular complexity of those elements and relations, which make up the history of atmospheric phenomena, whether on ocean or land. Such, and so close are these relations, that scarcely a change can occur in any one of them, without altering or disturbing more or less the balance of all. Science is now seeking to decipher these phenomena; and to obtain both more exact results, and knowledge of the relative influence of the causes producing them. But longer time and wider averages are required to this end; and meanwhile what becomes most needful is a patient and precise observation on all parts of the globe, and in all climes and seasons; aided by such an amount of *provisional* theory as may serve to the guidance of research, and to bind facts together until they can be submitted to the governance of general laws.

These considerations may mitigate a criticism to which Captain Maury's work is liable here, and indeed more or less throughout. He theorises too largely and hazardously, and

* In speaking of the influences of Light upon organic life, even in the depths of the sea, we would advert for a moment to those singular fossil crustaceans, the Trilobites. Found as far down as the Lower Silurian Rocks — the earliest known date of animal life, and far beyond all human measure of time — the eyes of these creatures are so well preserved in some specimens, as to show some four hundred spherical lenses composing this organ; indicating thereby not merely similar conditions of light, but also that the waters of the sea at this epoch were as transparent as in our own day. Conclusions of this kind, thus obtained and applied, are strikingly characteristic of modern science.

does not clearly separate the *known* from the *unknown*. His volume is replete with ingenious suggestions, but they are not methodised enough for the uses of the common reader, who will probably rise from the Chapters on winds and atmospheric currents, his head confused by a whirl of facts and theories and questions, as fleeting as the very air of which he has been reading. It must be admitted that this subject of the Winds of the ocean — whether permanent, periodical, or variable — is one of very difficult and intricate kind. The differences of temperature between the tropical and arctic regions, and the influence of the earth's diurnal rotation upon the currents of air thus produced, afford us a rational theory of the trade-winds. The periodical monsoons of the Indian Ocean, though depending in part on the same causes, are singularly modified by the proximity of great continents, islands, and mountain ranges; and though well known to practical navigators, their character is less certain and their interpretation more obscure. Still slighter is our knowledge of the variable winds, in those narrower seas where the influences of the land become predominant over those of the water; phenomena in which we in England have great practical concern, but to which it is at present difficult to give any systematic form.

The Barometer, though less certain here than on the wide Oceans of the globe, is still the instrument on which we may best depend; and the recent extension of its uses (aided by the electric telegraph), around the English coasts, will every year save hundreds of lives among the sailors and fishermen of our shores. It must however be kept in mind that our direct knowledge of the winds is derived from the lower strata of the atmosphere only. The aspects of clouds often show to the eye different or opposite currents at different heights: observations in balloons testify the same thing. Beyond this our conclusions, though inferential only, warrant us in be-

lieving the upper regions of the atmosphere to be traversed by currents of lesser density, but as determinate in space, time, and direction, as the winds which sweep periodically over the surface below. The general equilibrium is ever maintained; and this can only be effected by circuits and counter currents at different heights, according to the differences of temperature of each. The inference here approaches to a demonstration of the fact, though not reaching it by actual observation.

We cannot speak with the same assurance of a speculation, which however is sanctioned by eminent names, viz. that the more sudden and violent gales of wind, the tornadoes and whirlwinds of the seas, are due to the upper currents of air bursting abruptly into those of lower level; and by their different direction of movement, different temperature, and possibly difference of electrical state, begetting the various phenomena of storm on the ocean beneath. No better theory has yet been proposed for these sudden hurricanes; and in default of such, we must admit it as one of the many meteorological questions open to future research.

We should abuse the patience of our readers, were we to dwell longer on the subject of atmospheric currents thus encircling the globe, and, under their various conditions, aiding or endangering the labours of man on the seas. The only remark we have to add respecting Captain Maury's chapters on the atmosphere is, that he does not sufficiently allude to the influence of the variable weight of this great aërial ocean upon the ocean of waters below. Those who have attended to the phenomena and theory of the *Seiches* in the small basin of the Lake of Geneva, or witnessed the frequent and abrupt oscillations of a forty-feet water barometer, will be able to appreciate this element of unequal atmospheric pressure, as applied to the great watery surface of the globe. Nor do we find any allusion by our author to

the singular fact recorded by Sir James Ross, of the permanently low barometric pressure in high southern latitudes; or to the curious observations of Professor Airey and Mr. Birt, on the periodical rise of the barometer in the course of every month to some point above 30°; suggesting the notion of great atmospheric waves, ruffled by smaller waves in the intervals between. We must look to the future for a solution of these, and numerous other difficulties in meteorology, which are beyond the reach of any tables or averages yet obtained. Many of these phenomena may be best studied under the equator, where there is little variation in the sun's meridian altitude; where the zone of observation is symmetrically related to each hemisphere; and where the diurnal fluctuation of pressure is so regular, that the time may generally be determined within 15 or 16 minutes by the barometer alone.

The 'Depths of the Ocean,' and the methods employed to determine them, form an interesting chapter in the volume before us. Until a very recent time these methods were so far imperfect that, though numerous soundings were made into the more profound depths which sailors call *Blue water*, it could seldom be affirmed 'that fathom line had truly touched the ground' in these abysses of the sea. In the Southern Atlantic, more especially, results were given as obtained by British and American officers, which indicated depths varying from 26,000 to 50,000 feet, or from 5 to 9½ miles; and in several of these instances without any assurance of the plummet having reached the bottom. Here, in fact, lay the uncertainty of the whole process. Undercurrents might intervene, turning aside a slender thread and insufficient weight from the right line of descent; or, if allowing the weight to touch the ground, still acting upon the bight of the line, so as to cause it to run out too far from the reel in the vessel above.

We owe a better system of soundings to the active ingenuity of our American brethren on the seas. It was first decided that the twine used for this purpose must be of stronger texture; so as to bear the weight of at least 60 pounds freely suspended in the air. This sounding twine is divided by 100 fathom marks. The weight employed is a simple cannon ball of 32lbs. or 68lbs. weight, so appended, that on touching the ground it is detached from the twine; leaving, however, to reascend with the latter an ingenious little apparatus (the contrivance of Mr. Brooks of the United States Navy), which gathers and brings up specimens from the bottom of these deep recesses. Experiments made with lines thus constructed, have furnished a scale of the average time of descent for different depths; exact enough to tell pretty nearly when the ball ceases to carry the line out, and when, therefore, the depth is truly determined.

The result of these improved methods has hitherto been to indicate a lesser depth than was inferred from previous soundings. The greatest hitherto ascertained is in the North Atlantic, on the southern edge of the Banks of Newfoundland; where the ball touched the ground and parted from its line, at about 25,000 feet, or nearly five miles below the surface. Yet if Laplace's calculation of four miles as the mean ocean depth be correct, there must exist spaces with far deeper soundings than this. And such in truth we may expect to find, when navigators apply their present resources to fathom those other vast oceans, where the line has rarely been sunk for the purposes of science only; and where the phenomena of coral isles and volcanoes, show conditions of deep subsidence as well as elevation from physical actions occurring in the interior of the globe. The time may come, but yet is far distant, when we shall be able to map this great submarine territory with some approach to truth; and in so doing obtain, perchance, a further insight

into those wonderful changes, paroxysmal or gradual, which the outer surface of the earth has undergone in the course of ages, from central actions hitherto reached by conjecture alone. Knowledge need never be despaired of from any source, however seemingly remote, where the connection of the physical sciences is becoming so intimate in all its parts. A single instance may be given as peculiarly belonging to this Ocean of which we are treating. In a remarkable memoir by Professor E. Forbes on the 'Connection between the existing Floras and Faunas of the British Isles, and the geological changes which have affected this area,' we find denoted, amongst other curious local relations of certain British species to those of the nearest opposite continents, the singular case of identity of several species in the South-western Irish Flora, with species found not nearer than the mountains forming the northern coast of Spain. On various grounds Professor Forbes concludes — and he was not a rash speculator in science — that the British Isles acquired this connection of their Flora and Fauna with that of neighbouring lands, by immigration of species before the area they now occupy was severed from the greater continent. The specialty of the Irish case as to distance does not deter him from following out this conclusion. Boldly, but not without much show of reason, he draws a line of ancient continent across the Bay of Biscay and yet farther westwards into the actual Atlantic. Geology tells us of numerous changes and alterations of land and sea, similar in kind and still vaster in extent. Those changes which we may suppose to have visited Britain, though far removed from man's knowledge, are comparatively recent in the history of the earth — presumably of later date than what has been called the Meiocene epoch. It might seem as if a sort of specious reality were thus given to the ancient fable of the Atlantis:

but no history of time will serve us here, and this legend must be left in its old obscurity.

We cannot quit this topic of the depth of the Atlantic, without referring to one matter connected with it, far surpassing in grandeur of idea any fable of the imagination — we mean the Atlantic Electric Telegraph, so recently approaching its completion. The scheme, if not originating in a series of soundings across this ocean, was at least matured and directed by them. These soundings disclosed the existence, between Newfoundland and the western coast of Ireland, of a sort of plateau forming the bed of the sea, at a depth in no place exceeding 2,070 fathoms. This point of greatest depression is very nearly equidistant from Valentia and St. John's, the assumed eastern and western termini of the telegraph. The actual distance between these points is 1,900 statute miles; of which about 1,500 miles intermediate between the dips from each side, and named by Captain Maury the 'Telegraphic plateau,' afford a soft and singularly equable level. It is seemingly a surface of calcareous rock, covered in great part with a layer of microscopic tropical shells, and well adapted in every way to receive the wonderful instrument of human intelligence committed to this submarine bed. It was surmised, and not without show of reason, that these very materials, forming the bottom of the plateau, might furnish a coating of natural concrete to the electric cable; adding to its stability of position, lessening the chances of injury from the elements around, and possibly also affording a more perfect means of transmission of the electric action itself.

We cannot afford space, and it would be alien to our subject, to dilate on this extraordinary project; successful for a moment, then suddenly annulled, by causes which we apprehend will ever endanger submarine lines thus long and deep. We are not yet able to conjecture whether the

attempt will be renewed by any other line, or in any other form.* But we may well venture to affirm that delay is a lesser evil in this case than hasty and premature execution. Besides those risks to the coating of the wires and to their perfect insulation, which may depend on the depth and other less known conditions of the Ocean bed, we are obliged to admit that there are still difficulties in the theory of electric currents, and of electric actions by induction, which very especially apply to the case of long submarine lines for telegraphic use. Some of the several conditions which were suggested as likely to retard or otherwise impair a current thus prolonged, have been made the subject of careful experiment by those most competent to the research.† This enquiry is still in progress, including especially all that relates to the thorough insulation of the wires. So subtle is the agent they are called upon to transmit, and so liable to escape from its artificial channel, that a breach hardly perceptible to the eye might be fatal to the integrity of a line, otherwise perfect, across the Atlantic. We cannot better denote the beauty and ingenuity of the experiments applied to this object, than by stating that the electric current itself has been made to indicate, within certain limits, the point in the submarine wire where any fault or injury to insulation has occurred, even though this be hundreds of miles from the land terminus of the line. Scarcely indeed is

* Another telegraphic route to America has since been suggested (we are now writing in 1862) by the Faroe Isles, Iceland, Greenland, and Labrador; and partial surveys were made in 1860 to determine its feasibility. Such route would avoid any sea line, equalling in length that from Valentia to Newfoundland; but would incur various difficulties of execution and of maintenance in working state, greatly diminishing, if not annulling, the advantage thus gained.

† In connection with the experimental researches directed to the improvement of the submarine telegraphic cable, as well as to the best methods of 'rapid signalling,' by this great instrument, we must especially mention the name of Professor Thomson, of Glasgow, than whom no one is better fitted by his various acquirements, to solve the difficulties of the problem.

there any distance to which this principle of detection may not be applied, supposing that the defect is limited to a single spot only. The discerning of a fault, however, and even of the place of its occurrence, is much easier than its repair; and here will be found, we apprehend, the great practical hindrance to spanning the Atlantic by a telegraphic cable. The large expense of the work demands a security for its permanence which it will be very difficult, if not impossible, to obtain. The evidence derived from other and shorter submarine lines does not yet suffice to give this guarantee.

As to the practical results to the welfare of the world, and more especially of England and America, from the contingent completion of this singular work, we are not altogether persuaded by the current phraseology of the day. It is easy to affirm that whatever gives fresh facilities to human communication, is productive of good, and difficult perhaps to disprove the assertion. But in so stating the matter, we must keep in mind that it is the *speed of intelligence* only which is here chiefly in question. Doubts may suggest themselves, whether the farthing-a-pound fluctuations in the price of cotton deserve a daily transmission across the Atlantic; especially as the same means may be used to tell the fact almost simultaneously to every Liverpool broker or Manchester manufacturer. The demand for any particular article of traffic, whether raw or manufactured, is rarely so sudden or impetuous as not to be able to await transmission by the next steamer. A criminal fugitive may be arrested at the moment of landing, by his description outrunning him on the ocean, or relatives be brought sooner to a distant bed of sickness; but the simple tidings of friendship or family affection will not trust themselves to be interpreted by the vibrations of a needle, and the translations of a hired pen. Even in the more serious matters of diplomacy, we may doubt whether

the old-fashioned pauses in intercourse were not as salutary as these instant communications; giving longer time for passions to subside, and for first impressions to ripen by reflection; and preserving to the diplomatist a responsibility, equally essential to his own honour and to the interests of the country he represents. In time of war (*absit omen!*), the advantages obtained may be more numerous and certain. But even here we must balance them against the effects of lessened responsibility to those engaged in the duties of actual command; and of faulty information at a distance superseding the better judgement derived from local knowledge. We are aware however that there is a double aspect to all these points; and without pressing further any such ambiguous presages, we shall be ready to join in the general gratulation on the success of an undertaking thus wonderful as an effort of human genius and power; and destined, we trust, to link together still more closely in amity as well as intercourse, the two great nations already having kindred in origin, language, and common liberties.

We have occupied so much space with the various topics, that our notice of the other parts of Captain Maury's volume must be a very limited one. In a chapter on the 'Salts of the Sea,' he propounds his views, and perhaps with some exaggeration, as to their influence in creating ocean currents by the different specific gravity of strata of water differently charged with salt. To the curious question regarding the origin of this saline matter, (amounting to three and a half per cent. in the average of all seas,) he answers that it was thus when the Ocean was created; that no washing down of salts by rivers can adequately explain the phenomenon, and that the 'Christian man of science' may rest his belief, on the absence of any proof from Scripture that the sea waters were ever fresh. Even accepting the conclusion as probable, we must repeat our remonstrance against this mode of

stating it. The question in itself is one of much difficulty, and we can see no evidence that it is ever likely to go beyond presumption. The uniformity in the quantity, quality, and proportion of the saline constituents, and the fossil animal remains of ancient *Salt seas*, now found many thousand feet above the ocean surface, would seem the strongest proofs of identity of state from the beginning. The presence in all sea-water, though in most minute proportion, of those singular elements (or what are provisionally called such) Iodine and Bromine, becomes a special part of this argument, and cannot be neglected. We do not venture to cite to the same effect the recent discovery of Silver, as another ingredient; since further experiments are needed to attest its universality*; and perhaps we must yet postpone that still later discovery (1861) of Lithium in sea-water, by the new and marvellous method of the spectrum analysis. But all these researches show in their results the complex and wonderful nature of that ocean-fluid, which wraps round so large a part of the solid globe.

In treating of the various ocean temperature, and its influence in producing currents, we do not observe any notice of that singular and important discovery which we owe to Sir James Ross; viz., the existence of a stratum of *invariable temperature* (39½° Fahrenheit), pervading the ocean from north to south, and represented on each side the equator by a similar

* The discovery of silver in sea-water by Malaguti and Durocher, is curiously confirmed by certain experiments of Mr. Field, showing the presence of silver, even to the amount of seven ounces to the ton, in the copper sheathing of ships after long-continued voyages. These observations are related in a paper read to the Royal Society some months ago.

We may notice here the curious experiments of Professor Chapman of Toronto, as to the comparative rate of evaporation from salt and fresh water. They show that the greater the proportion of salt, the slower the evaporation; and that water containing the same percentage as that of the sea, loses in 24 hours not quite half as much as fresh water. This fact gives some support to Mr. Chapman's theory, that one great use of the salt in the Ocean is that of regulating and controlling the evaporation ever going on over its vast surface.

and very curious curve, depending on the superficial heat or cold in different latitudes. At the equator the depth of this level of constant temperature is 7,200 feet; — in latitude 56° it is at the surface; — in the Arctic regions it descends again to 4,500 feet; the temperature in each case being invariably the same (that is 39½°), below the level of these several depths. The value of such observations to every theory of submarine currents will readily be perceived.

To the domain of the North Atlantic belong those Arctic Seas, which, stretching northwards on each side of the projecting continent of Greenland, lead on the western side to the ice-bound recesses of Baffin and Hudson Bays — on the eastern to Iceland and Spitzbergen, possibly even wrapping round the Pole itself; though we are yet ignorant (as in the case of the southern Pole also) whether this great axis of our globe terminates in land or water. These northern seas have been during the last forty years the scene of those bold and perilous enterprises of English navigators, which give us so much to admire; alloyed by one great calamity which we can never cease to deplore. The problem of the North-west passage solved, and its utter uselessness ascertained, the stern regions of the Northern Coast of America may wisely now be left to their primitive solitude. If other attempt be made hereafter in Arctic discovery, we would fain see it take a direction to the *east* of Spitzbergen; — a route hitherto unattempted by English navigators, and which would be aided by means wholly unknown in the earlier days of Arctic discovery. We confess our desire that the nearest approach of man to the pole of his planet should be due to English enterprise and perseverance.

In a chapter on 'Ocean Routes' our author gives some graphic narratives of that racing on the high seas, which, if it be the pride and profit of modern navigation, is also oftentimes to be accounted its folly and peril. The struggle for

superiority, whether by sail or steam, is still almost exclusively between England and the posterity of England in America; the two great commercial communities of the world. Though the Indian and Pacific Oceans form part of the scene of contest, the Atlantic is the arena where science and skill, aided by abundant capital and incited by strenuous emulation, have achieved results which only a quarter of a century ago would have been deemed impossible. These results are too well known to need relation here; but we may notice briefly one or two facts, illustrating the wonderful changes now in progress in commercial navigation. We should scarcely err in stating the average duration of long ocean voyages — as those to or from China, Australia and India, performed by the best sailing ships — at barely half what it was at the period just named. Among the causes concerned in this great result must first be noted, the improved construction and fitting of ships; and especially with reference to what Mr. Russell has called the *wave principle of construction*; or, in other words, the form of least resistance of a solid moving through water. Connected with this, and in practice now applied to the same end, is the direct relation ascertained to exist between the length of the vessel, and the speed it is capable of attaining. But beyond these altered conditions of the vessel itself, comes in the enlarged and more exact knowledge of the seas it traverses; of the winds and currents, the shoals and depths, and the various other physical phenomena of the ocean, which have been brought to the aid of practical navigation, and to which we have already so copiously referred. To the combination of these causes, and the record of the tracks and times of many hundred voyages, upon methods which Captain Maury has done much to enforce, we owe those feats of seamanship, which have brought India and our Australian colonies within ten or twelve weeks of England, and made the circumnavi-

gation of the globe as frequent and familiar as was once the passage across the Atlantic.

We have here been speaking of sailing vessels, but Steam navigation has its own peculiar history; including not only these several improvements, but others also which depend on more perfect machinery and a higher class of engineers. Though steam has now spread its dominion over the globe, the Atlantic is still the sea where it puts forth its greatest powers. The several lines of Mail Steamers across this Ocean, and more especially those familiarly known as the Cunard and Collins lines, have reached a degree of speed and regularity, which it would be hazardous to say may not hereafter be surpassed, but which will ever be a monument and mark of human prowess, in bringing the physical elements under subjection to the uses of man. It is no serious disparagement to the second of these lines, to say that it has lost the superiority for a short time gained in speed over the Cunard line of English steamers. According to an American statement now before us, we find that, during the last year, the average of twenty-five passages from Liverpool to New York, by the American steamers, was 12 days 16½ hours — by the English steamers, 11 days 22 hours: of passages from New York to Liverpool, by the American vessels, 12 days 8 hours, — by the English, 11 days 3 hours. Many circumstances concur to this result; chiefly perhaps the consummate discipline of the English vessels in every department of their service. But the rivalry we regard as an honourable one; and it may yet be maintained, advantageously to the interest of both nations.*

It is however, as we have said, a rivalry not without risk. In seeking for the maximum of speed, safety is jeopardised

* About two years after this article was written, the competition here alluded to ceased, from the abandonment of the Collins line of steamers. That of Cunard still maintains, unimpaired, its high position on the seas.

in all these great lines of mail steamers. Winter storms, icebergs, fogs, cyclone-hurricanes, and collisions with other vessels, are all encountered at high rates of velocity, and with many calamitous results. Experience and discipline have done much to protect against these dangers, but serious hazards still exist; and especially those of collision, which are constantly augmenting in an ocean every year more crowded with ships, seeking to find the shortest passage across it. In these days, however, of bold design and prompt execution, there are few ills which do not bring with them the suggestion of remedy. Captain Maury, and others in sequel to him, have urged the adoption of '*steam lanes*' across the Atlantic; — that is, well-defined lines of navigation of a certain width, and separate from others throughout; so appropriated respectively to vessels going east or west, that the chances of collision may be greatly lessened if not altogether removed. The width of the zone of ocean, now traversed by the mail steamers to North America, is about 250 miles. It is proposed to mark off *lanes*, 20 or 25 miles in width, on the northern and southern borders of this zone, as the routes respectively to be followed and adhered to by all steam vessels crossing in one direction or the other. The scheme, or some one equivalent to it, we doubt not to be practicable; and such is its obvious utility, that we as little doubt its being eventually carried into effect. The phrase of a *Steam lane* may somewhat startle those who are wont to associate with this word the cross roads of a midland rural district in England — the high hedges, deep ditches, and straggling cart ruts; the bushes of blackberry, hazel-nut and hawthorn; and the hundred sweet flowers and weeds which luxuriate on the hedge banks. We cannot quarrel, however, with this novel use of the term, if the object be fulfilled to which it is applied. If *long lanes* of ocean, 'which have no turning,' be really laid out for the safer navigation of the seas, a great

point in maritime economy has been achieved. The very simplicity and familiarity of the name so given is a tribute to that prowess of man, which has taught him thus to mark out and pursue a fixed path through the wide wilderness of waters.

Though not having exhausted the subject of the Atlantic, either in its physical features or in its relations to human industry and power, we stop here. The points we have touched upon will show how copious and interesting a topic, under both these aspects, is the 'Physical Geography of the Sea;' and how worthy to be embodied with the other great subjects of human knowledge, which at this time enlighten and animate the world. Every year enlarges its domain; and we may fairly predict that the history of the Atlantic, written twenty years hence, will be a record of numerous physical facts, now either unknown or dimly and doubtfully understood. Whatever their particular nature, we may be certain that they will tend to illustrate that mutual connection among different branches of knowledge, to which every day is adding further testimony.

THE MEDITERRANEAN SEA.*

[Edinburgh Review, October, 1857.]

COPIOUS, even to excess, as is the literary labour of our age, and ever seeking new topics or new methods of vivifying old ones, there are yet subjects to be found, either not touched upon at all, or scantily and incidentally treated without due regard to their proper value. Void places of this kind still occur in the history of men and nations; gaps which it will belong to future genius and research to fill up, by aid of the fresh materials ever accumulating around us. The laborious activity of German literature has gone farther than that of any other country, in finding such new fields and fertilising them by its industry. But others yet remain to be opened, even in the records of human events; still more in the great domain of natural history and the physical sciences. Here especially the rapid growth of knowledge has created the need of fresh divisions in every part; of altered nomenclature; and particular treatises on topics, the increasing importance of which compels their separation from others with which they were before associated.

In a recent article of this Review, we referred to the 'Physical Geography of the Sea,' as one of the many instances in which science has required and adopted this

* *The Mediterranean. A Memoir Physical, Historical, and Nautical.* By Rear-Admiral William Henry Smyth, K.S.F., D.C.L., F.R.S., &c. London, 1854.

This Article was written in great part during a voyage to Syria, Palestine, and Egypt in 1857. But I may speak of it as founded on more than twenty previous voyages throughout every part of the Mediterranean Sea.

more specific record of a particular class of natural phenomena; and in discussing the subject we carried our limitation yet farther, by taking the Atlantic as the special exponent of those features which belong to the ocean domain of the globe. We have now before us a volume on the Mediterranean Sea; the first English work, as we believe, expressly devoted to this subject. Its coasts and islands have been separately noted and described by travellers, geographers, and historians of all countries and ages. But no one had treated, singly and especially, of the Sea washing round and amidst these lands, and reflecting their wonderful history of thirty centuries on its waters. We possessed no work delineating its peculiar physical features; — its outline, dimensions, depth, currents, winds, and other hydrographical and nautical conditions;—the configuration of its coasts, its islands, volcanoes, and the rivers which pour themselves into its great basin.

This, then, was one of the voids of which we have spoken; and it continued such, until the progress of all scientific knowledge and the rapid spread of human intercourse by sea and land, made it needful that a physical history of the Mediterranean should be written; — an object well and ably fulfilled by Admiral Smyth in the work before us. Some time has now elapsed since its publication; but intervening events have enhanced the interest of the subject; and we willingly receive his volume as the first instalment of what is due to the general history of the Mediterranean Sea.

In a mere technical sense, the Mediterranean may be described as a gulf or inland branch of the Atlantic; but in itself this Sea has a more wonderful individuality than any other on the globe. This is true as to its physical features, singly considered; — still more eminently true as respects those relations to human history which render it an interpreter of the records of past ages, and of the ancient empires which have flourished on its shores. On no equal

area of the earth's surface have so many and such mighty events been crowded together as within this extraordinary basin. Every keel which now cleaves its waters traverses the scene of some maritime struggle or adventure of old times and earlier races of men; or skirts shores hallowed to the scholar or historian by the memory of genius or grandeur which have passed away. Empires, kingdoms, and republics, born to sway the destinies of the world, have risen and declined upon its coasts. Schools of philosophy and eloquence, to which we still recur for instruction and example; — laws and languages, which are embodied in the literature and social institutions of every later age, — had their earliest seats around this inland sea. It is difficult to touch upon the subject thus generally without becoming too rhetorical; but we hope, in dwelling upon some of its details, to show how copious and full of interest it is, and how well meriting the special attention of some writer who may make it, as a single picture, more complete and familiar to our knowledge. The events of history are best bound together by such local associations; and none more so than those of which the Mediterranean has been the scene and centre during a long succession of ages.

It may further be alleged as an argument for such a work, that the interests of England are deeply concerned in all that regards this Sea. Of late years certain foreign writers and orators, rather political than geographical in their style and spirit, have used the term of *lake* in describing it. The Mediterranean is certainly not *our lake*; nor can it, nor ought it, ever to pass under the supremacy of any one Power. But we have large insular possessions within its circuit; we hold the mighty rock-fortress, the Calpe of antiquity, which commands its entrance from the Ocean; and we crowd its waters to their very extremity with our ships and commerce. That single line of Mediterranean navigation, which ministers to

the rapid intercourse with our Indian Empire, through Egypt and the Red Sea, is in itself an interest of primary importance to us, and never more so than at the present moment. The communication thus opened has already reached a speed and regularity of service which place it among the highest efforts of human prowess on the seas. If other and better routes be hereafter obtained through the Persian Gulf), (which is still matter of doubt), equally must we depend on the Mediterranean for a line of passage to that part of the Asiatic coast giving easiest access to the valley of the Euphrates. More recently the mail route through this Sea has been taken as the first stage to our Australian colonies; — the shortest line, following the earth's curvature, between England and the great Island-Continent, on the opposite side of the globe. It is a wonderful route to a wonderful country; each attesting that national energy and power which has brought a new people into birth, and made oceans and seas tributary to the communication with the parent land. The discovery of the Australian gold-fields has doubtless quickened these results, but time would have evolved them even without this great auxiliary.

All these things are now become familiar to us; but we nevertheless specify them, because their very familiarity is apt to abate our wonder, and to dissever them from those memorials of older times and things, to which they stand in such singular relation and contrast. Nor must we forget, while speaking of English interests in the Mediterranean, those vast naval and military armaments so recently borne on its waters to the mighty struggle before Sebastopol; — an effort of concentrated power, rising with the need, and greatest at the very moment when peace suspended its further action. These armaments in their course passed along shores and through straits, every bay and promontory of which has its place in ancient poetry or history; and

within sight of one especial spot on which the genius of a single man (for such we believe him to have been) has bestowed an imperishable fame. It might seem ungracious towards those officers who carried with them so much spirit and bravery to the battles and privations of the Crimea, to enquire too sceptically what proportion of their number were fully conscious of the objects their voyage brought into view? — how many of them saw with the eyes of history the mountains of Lacedæmon, Scio's isle, the plain of Ilium, and the crests of Ida and the Asiatic Olympus? or felt emotion in passing through those two straits, so famous in the history and poetry of every age?

We put the question designedly; but more in regret than reproach. For we are compelled to admit that no adequate provision has hitherto been made for the special instruction of those numerous Englishmen who are called by military, naval, or colonial duties to every part of the habitable globe. The greatness of our empire, and the progress of knowledge and invention in all that regards the social condition of man, make at this time a necessity of what was heretofore only a matter of expediency. In proportion to our power is the magnitude of the duties we are called upon, as a nation, to fulfill; and one of those duties is that of sending out to the defence and administration of our distant possessions, men well fitted by temper and education to discharge their functions with integrity and intelligence; — the latter, in most cases, the best guarantee for the former. It is our sincere belief, that no one is so well calculated to fulfill these conditions as the English gentleman, in the highest intellectual and moral sense of the word. But care is needful that the standard be not lowered, either in comparison with our former selves, or with the people of other countries, at a time when all things are in a state of transition; and when much exists, in the rapid intercourse of the world, and the

various and desultory objects before men's minds, tending to lessen the force of individual character, and to disperse the energies of thought and action too widely for their highest efficiency. True genius will rise above these and other hindrances; but we are bound to provide also for those minds of a lower grade, by whom, in effect, nine-tenths of the world's business is carried on. We gladly perceive in all that is in progress around us, a growing attention to these objects, in which England has deeper interest and concern than any other State on the face of the globe. She has not only to sustain 'her precedence of teaching nations how to live,' but to maintain unimpaired her own great life — her liberties, laws, and language — and to enlarge and perpetuate their influence on ages yet to come.

We have been led somewhat away from our subject by this question as to the sufficiency of English education, in its ordinary form, for travel in lands of classical antiquity; — a question we are compelled reluctantly to answer in the negative. Notwithstanding the time given to Greek and Latin studies in the schools and colleges of England, our youth go forth — learned, it may be, in hexameters and iambics — but wanting generally in those higher classical associations which localise the history, poetry, eloquence, and philosophy of past ages, and illustrate the revolutions of men and nations by the more lasting memorials of nature. We must not be understood here as invoking any maudlin sentiment on these matters, such as too often finds its way into books and narratives of travel; — the produce rather of after-concoction at home than of honest enthusiasm on the spot. But we wish for such previous knowledge to be brought to places illustrious in the world's history as may enable the traveller, if not to investigate and discover, at least well to understand and enjoy. Much, we conceive, might be done towards this end, by combining with common

classical instruction a more copious and vivid illustration of the lands which have given birth and subject to this part of learning; and by admitting even the physical sciences to contribute their share to such illustration. It may be urged that this would require a higher competence and more various knowledge in those to whom the act of teaching is committed. We admit the inference, but do not on this account withdraw or abate the demand to which it applies. If what we have pointed out be recognised as desirable, the means and methods of attainment are sure in these days to be found.*

The volume of Admiral Smyth on the Mediterranean has various merits, which we fully appreciate. As a writer, he is chargeable with some little eccentricities of style; but he brings to his subject great nautical and scientific knowledge, much earnestness of purpose, and the results of an active personal survey of many coasts of this Sea; and of some, especially on the African side, before imperfectly known. His work is dedicated to the veteran Admiral Beaufort; whose long labours as Hydrographer to the Admiralty have well and worthily sustained the reputation he acquired from his admirable researches on the coasts of Asia Minor. Admiral Smyth's own labours are honourably attested by a catalogue of more than one hundred charts presented to the Admiralty; and by numerous facts in relation to currents, tides, soundings, winds, and other aqueous and atmospheric

* The institution of the Geographical Society of London, and the zeal with which its objects are pursued, is well calculated to forward the object of teaching travellers *where* and *how* to travel, and what objects still remain to be fulfilled. We gladly see attached to it the names of some members of the 'Yacht Club;'—itself a national institution, peculiar to England, and admirably fitted to sustain that national vigour and enterprise on the seas, upon which our greatness as a State so essentially depends. We honour this spirit of enterprise in the recent exploit of Lord Dufferin, who, in his little yacht of 80 tons boldly entered the Arctic seas; visiting Iceland, Jan Mayen's Isle, and even the icy coasts of Spitzbergen, as far north as lat. 78° 44′.

phenomena, which make up the physical history of this great sea. We have no right to complain that the volume before us is devoted chiefly to professional objects, since these are numerous and of eminent value. But the subject admits of a wider delineation and more ample details, physical, historical, and picturesque. A work comprising these, and at the same time preserving entire the unity of the picture, is still wanting to our literature.

The very familiarity of the Mediterranean in our own days has begotten a certain indifference to its peculiarities and grandeur. Looking to physical features only, it is by far the most wonderful ocean-inlet or midland sea in the world; penetrating farther into the heart of the continent than any other, and more strangely broken and diversified in its outline by gulfs, straits, islands, and inner seas. Mere verbal description does little towards illustration in a case of this kind. A map or globe must be before the eye, and the Mediterranean looked at simply and singly in its boundaries and dimensions; putting aside all local associations which disturb such general view.* It will be seen at once how singular and curious is the configuration of this vast basin; how deeply its gulfs run into the lands which surround it; and how closely they approach at its eastern end those other deep inlets of the Red Sea and Persian Gulf, which have their connection with the Oceans of another hemisphere. The eye, cast over other parts of the globe, will see nothing

* This direction will not seem superfluous to those who have watched the curious mechanical results of habit, even in the simple matter of relative position of objects before the eye. Any one may satisfy himself of it in this instance by merely inverting a map, or turning a globe into some unwonted position, when he will seemingly have before him a totally new configuration of land and sea, which it requires some time and effort to bring back to the reality of his former recollections. The experiment is worth making as a special illustration of a large class of mental phenomena, which cannot be too carefully studied as a part of psychology.

equal or comparable to it in these physical peculiarities. Dante, whose descriptions of nature are often as exact as they are always sublime, speaks of it as —

> La maggior valle in che l' acqua si spanda,
> Fuor di quel mar che la terra inghirlanda.*

Those, moreover, even least tutored in modern geology and the great phenomena with which it deals, will see that mighty movements and changes must have occurred here during ages far anterior to human record or human existence on earth. We shall hereafter refer to some present proofs of these remote events (whether slow or paroxysmal in kind) in the volcanoes and earthquakes which still so singularly affect the basin of the Mediterranean. Meanwhile, a superficial view will show us this sea exchanging its waters with those of the Atlantic at one extremity; at the other, nearly 2,000 miles distant, dissevered but by a low and narrow isthmus from those which belong to the Indian Ocean. Throughout the whole of this distance it divides Europe from Africa, physically and socially the two most dissimilar portions of the globe; — the '*discordanti liti*,' as Dante calls them, in the very passage from which we have just quoted. The continent of Asia closes its eastern extremity; and the Asiatic line of coast, including that of the Black Sea, which may be regarded as its inner basin, stretches nearly 2,500 miles in length. The total circumference of the Mediterranean, following the line of its great gulfs, is estimated at upwards of 13,000 miles. Its area, including the Black Sea and the two Seas of Azof and Marmora, is stated by Admiral Smyth to be 1,149,287 square statute miles.† These are magnificent

* Paradiso, canto ix. 82.

† In some other works a much lower statement is given of the superficial extent of the Mediterranean; but this may probably depend on the omission of the Black Sea and its subordinate basins, and on the use of the geographical instead of the square statute mile: — possibly, also, on a deduction made for the surface occupied by islands.

dimensions; and rendered more striking by its profound depth, of which we shall presently speak, and by the lofty mountain-chains which form its coasts, or rise as islands from amidst its waters.

The name of Mediterranean does not belong to the ancient history of this sea, and is not found in the earlier geographers either of Greece or Rome. To the people of Palestine it was emphatically 'The Sea,' or the 'Great Sea.' To the Greeks and Romans it was the Sea within the columns, the *Mare Internum*; *Nostrum Mare*; or still more frequently described in history and poetry under the various local names derived from adjoining people or coasts. The word Mediterranean is not found, we believe, before the third or fourth century, appropriate though it be in the sense of a general description. Other names of common currency may still be heard among the motley traders in this sea; but they are not recognised in our maps, and it is not needful to enumerate them. Those, on the other hand, connected with its great natural divisions, as the Adriatic, the Archipelago, &c., are necessary in themselves, and sanctioned by long and familiar historical use.

These divisions are of considerable interest in the physical history of the Mediterranean. As many as seven have been suggested and defined; but we may content ourselves with denoting one, which is instantly obvious to the sight as breaking the Sea into two great, though unequal, basins; and not less strikingly marked by certain natural features, which coincide with and illustrate the simple geographical fact. This is the partition made by the long peninsula of Italy, the island of Sicily, and the projection of the African continent at Cape Bon;—leaving a passage barely eighty miles in width between the western and eastern basins of the Mediterranean. The fact thus obvious to the eye is physically expressed by the lofty ridge of the Apennines stretching along Italy to its very extremity, and re-appearing in the

Neptunian Mountains of Sicily; and beyond this by a bar or line of shallow sea, occupying the strait between Sicily and Africa, and separating the profound depths which lie on each side of this submarine ridge. Though a part of the line be thus submerged here, as well as in the narrower breach forming the Strait of Messina, the physical fact is even rendered more striking by this submergence; and brought more closely into relation with those geological changes which have moulded the surface into its present shape and aspects. And that great subterranean forces have actually been at work in this barrier line, we have evidence equally curious and instructive, in the volcanic phenomena, present as well as extinct, which are notable throughout its whole extent; — not uninterruptedly indeed, but so connected in proximity and direction as to give them an evident relation to a common physical cause. At the northern end of the line we find the volcanic rocks of the Euganean Hills; amidst which, in the village of Arqua, stands the secluded tomb of Petrarch. Coming southwards, a long tract of extinct volcanic formations stretches through the Roman States. Yet again, farther south, lies the region of Vesuvius and the Campi Flegrei; wonderful in its present phenomena, and not less so in those which belong to ages anteceding any known history. Following the line farther, we come to Stromboli and the Lipari Isles, still emitting flames and volcanic